Carbon Accounting & How We Can Build More Sustainably

Sustainable Forestry and the Environmental Attributes of Wood Structures

Presented by

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Life Cycle Assessment: Embodied Carbon and Biogenic Carbon

Fossil $\text{CO}_2$  

Biogenic $\text{CO}_2$
Biogenic Carbon Neutrality: Definition

1. **Carbon neutrality** as a property of wood or other biomass harvested from forests where new growth completely offsets losses of carbon caused by harvesting.

2. As carbon is released from harvested wood back into the atmosphere, usually as biogenic CO2, growing trees are removing CO2 from the atmosphere at a rate that completely offsets these emissions of biogenic CO2, resulting in net biogenic CO2 emissions of zero or less.

3. A forest producing carbon neutral wood will have stable or increasing stocks of forest carbon.

4. Forestland should continue to be forestland, either through plantation or natural regeneration (ensure no land use change).

Definition by the Forest Solutions Group (FSG)
System Boundary and the LCA concept of neutrality

Annual Net Sequestration 21.0 mil ton CO$_2$e

Net Annual Seq of CO$_2$e Implying stable or increasing forest stock

Biogenic CO$_2$

Annual removal 14.5 mil ton CO$_2$
Biogenic Carbon **Neutrality** and Biogenic Carbon **Storage** (e.g., of WA State)

2015 WA State Private Forests

**Annual Net Sequestration** 21.0 MT CO$_2$e

- **Residue, Hog Fuel, Waste**: 9.7 MT CO$_2$e
- **Merchantable Biomass**: 4.8 MT CO$_2$e

**Annual removal** 14.5 MT CO$_2$e

**2.4 MT CO$_2$e** Carbon in products

**Pulp and Paper**
- 7.3 MT CO$_2$e
  - 50%
  - 15%
  - 35%
LCA based Embodied Carbon Calculation of MASS TIMBER BUILDINGS

- Mature Stand
- Growing Stand
- Selective Harvest
- Site Preparation
- Wood Products Production and Transportation
- Cross-laminated timber
- Glulam
- Co-products
- Functional Life of the Building
- Mass timber building
- End of Life of Wood Products
- Landfill
- Incinerator
- Recycling

Total Embodied carbon

Steady/Growing C stock in the forests

C stock in wood products
Functional equivalent buildings: Mass Timber vs. Traditional Concrete Structural Designs

<table>
<thead>
<tr>
<th>Stories</th>
<th>Building Height (meters)</th>
<th>Total Floor Area (m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>26</td>
<td>9,476</td>
</tr>
<tr>
<td>12</td>
<td>48</td>
<td>14,214</td>
</tr>
<tr>
<td>18</td>
<td>71</td>
<td>21,321</td>
</tr>
</tbody>
</table>

System Boundary

<table>
<thead>
<tr>
<th>PRODUCTION STAGE</th>
<th>CONSTRUCTION STAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>A2</td>
</tr>
<tr>
<td>Extraction and upstream production</td>
<td>Transport to factory</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>Transport to site</td>
</tr>
<tr>
<td>Installation</td>
<td>Installation</td>
</tr>
</tbody>
</table>
PNW Material Contribution to GWP

MT reduction in GWP
43% - 8 story
44% - 12 story
30% - 18 story
COMPARISON BETWEEN THE THREE CASE STUDIES

- PNW uses more concrete and less mass timber compared to SE and NE to meet the requirements of the seismic design.
- The three case studies use wood species mix with density values in the order: SE > PNW > NE.

**Wood density**

- SE (Southern Yellow Pine) density: 616 kg/m³
- PNW (Western Hemlock and Douglas-fir) density: 466 kg/m³
- NE (Eastern Spruce and White Pine) density: 434 kg/m³
The reduction in embodied carbon ranged from 22% to 50% across all the regions and building types.
GLOBAL WARMING IMPACTS OF EMBODIED AND SEQUESTERED CARBON
PER SQUARE METER OF AN 12 STORIED BUILDING IN PNW

100 year global warming impact
157.3 CO$_2$e
GLOBAL WARMING IMPACTS OF EMBODIED AND SEQUESTERED CARBON
PER SQUARE METER OF AN FOR A 12 STORIED BUILDING IN PNW

100 year global warming impact
157.3 kg CO$_{2e}$

80 year global warming mitigation
240.3 kg CO$_{2e}$
GLOBAL WARMING IMPACTS OF EMBODIED AND SEQUESTRERED CARBON
PER SQUARE METER OF AN FOR A 12 STORIED BUILDING IN PNW

8 STORIED BUILDING IN PNW

- Annual GWP contribution of embodied energy 8-story
- Annual Biogenic GWP contribution Biogenic Carbon Storage 8-story

100 year global warming impact
129.1 CO₂e

80 year global warming mitigation
227.4 CO₂e

18 STORIED BUILDING IN PNW

- Annual GWP contribution of embodied energy 18-story
- Annual Biogenic GWP contribution Biogenic Carbon Storage 18-story

100 year global warming impact
167.3 CO₂e

80 year global warming mitigation
208.3 CO₂e
NET GLOBAL WARMING POTENTIAL OF MASS TIMBER BUILDINGS COMPARED TO CONCRETE BUILDINGS

Building lifetime: 80 years
CONCLUSIONS

- **Including biogenic carbon storage benefits** in the GWP evaluation, and assuming a building life span of 80 years, mass timber buildings show a **net negative GWP** in all case studies and in all building designs.

- When considering only embodied carbon, CLT buildings may result in 22% - 50% reduction in global warming potential.

- However, when we factor in the benefits of long-term carbon storage, CLT buildings may account for 118% to 215% reduction in global warming potential as compared to traditional structures.
Thank you!

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END-OF-LIFE CONSIDERATIONS

- End of life (EoL) scenarios were not a part of Phase I of the current study, but they can influence the overall environmental impact of concrete and timber buildings.

- The reuse of CLT and glulam at the end of one building life into another building life or economically reprocess into new products for new applications will significantly influence the GW impacts.

- In the case of CLT, if panels can be directly reused, the need for raw materials will be reduced and will have a lower embodied carbon and energy at the start of its new “life”.

- This potential reuse of CLT not only reduces the impact of producing new materials, but also extends the period of carbon stored in the wood.

- The final treatment option of building materials is strongly dependent on regional policies.