



Creating forest sector solutions

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Environmental Performance of Cross-Laminated Timber

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Possible Environmental Questions for CLT

- Is there enough **forest** to sustainably support manufacturing?
- Does it contain **recycled** material?
- Does it minimize the use of **materials**?
- Does it reduce operating **energy** in buildings?
- Does it have less **embodied** environmental effects than alternate materials (energy, water, greenhouse gases, etc)?
- Does it adversely affect **indoor air quality**?

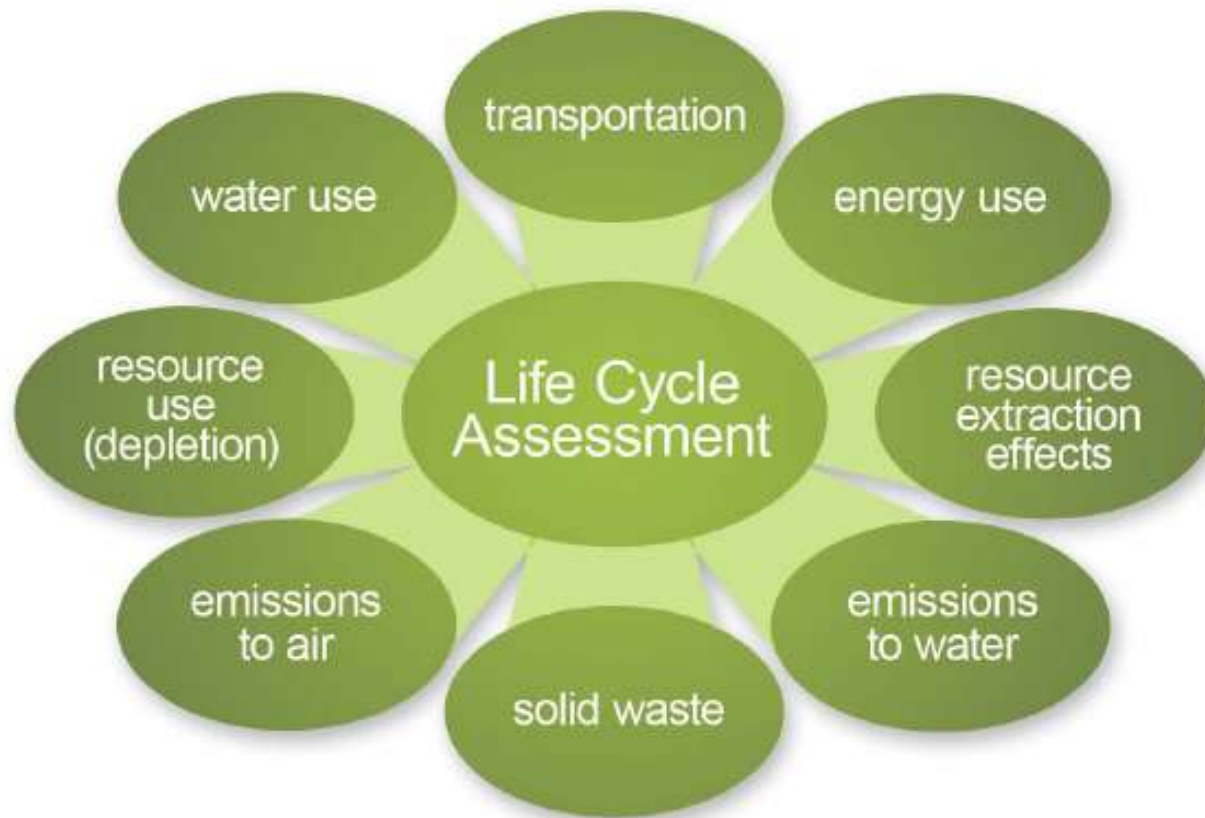
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Addressed in this presentation

Environmental Profile Using Life Cycle Assessment

LCA is a rigorous, scientific accounting of flows to and from nature related to a product over its entire life span



Our Approach

- No existing LCA data on CLT publicly available.
- Not in our scope to do a primary LCA.
- Performed a snapshot mid-rise comparison using glulam as a proxy for CLT.
- Used secondary data to approximate an LCA for CLT manufactured in Canada.
- Compared a CLT floor section to a functionally-equivalent concrete floor section.
- Reviewed related literature to help draw conclusions.

Mid-Rise Comparative Snapshot - Approach

What is the footprint of Stadthaus compared to a reinforced concrete alternate?

Modeled with the Athena Impact Estimator (whole-building LCA software)

Base Case

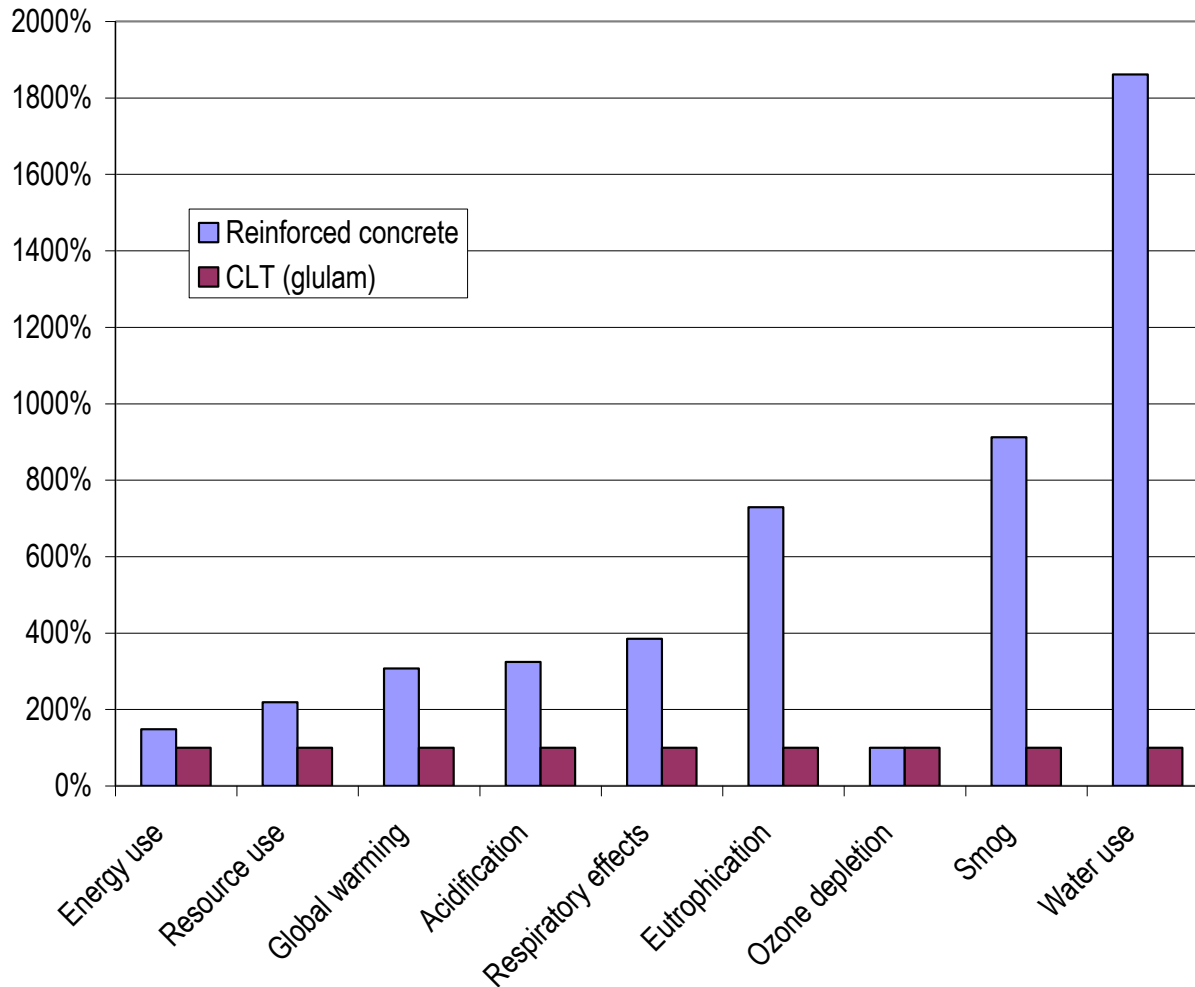
- 910 m³ CLT.
- Modeled as a glulam column-beam system with additional glulam.
- Results are missing added fasteners and added construction effects.



Alternative

- 950 m³ concrete and 120 tonnes steel reinforcement.
- Modeled as concrete slab-column-beam system with additional concrete and steel.
- Missing some components and effects, and may be missing interior walls.

Mid-Rise Comparative Snapshot – Embodied Results



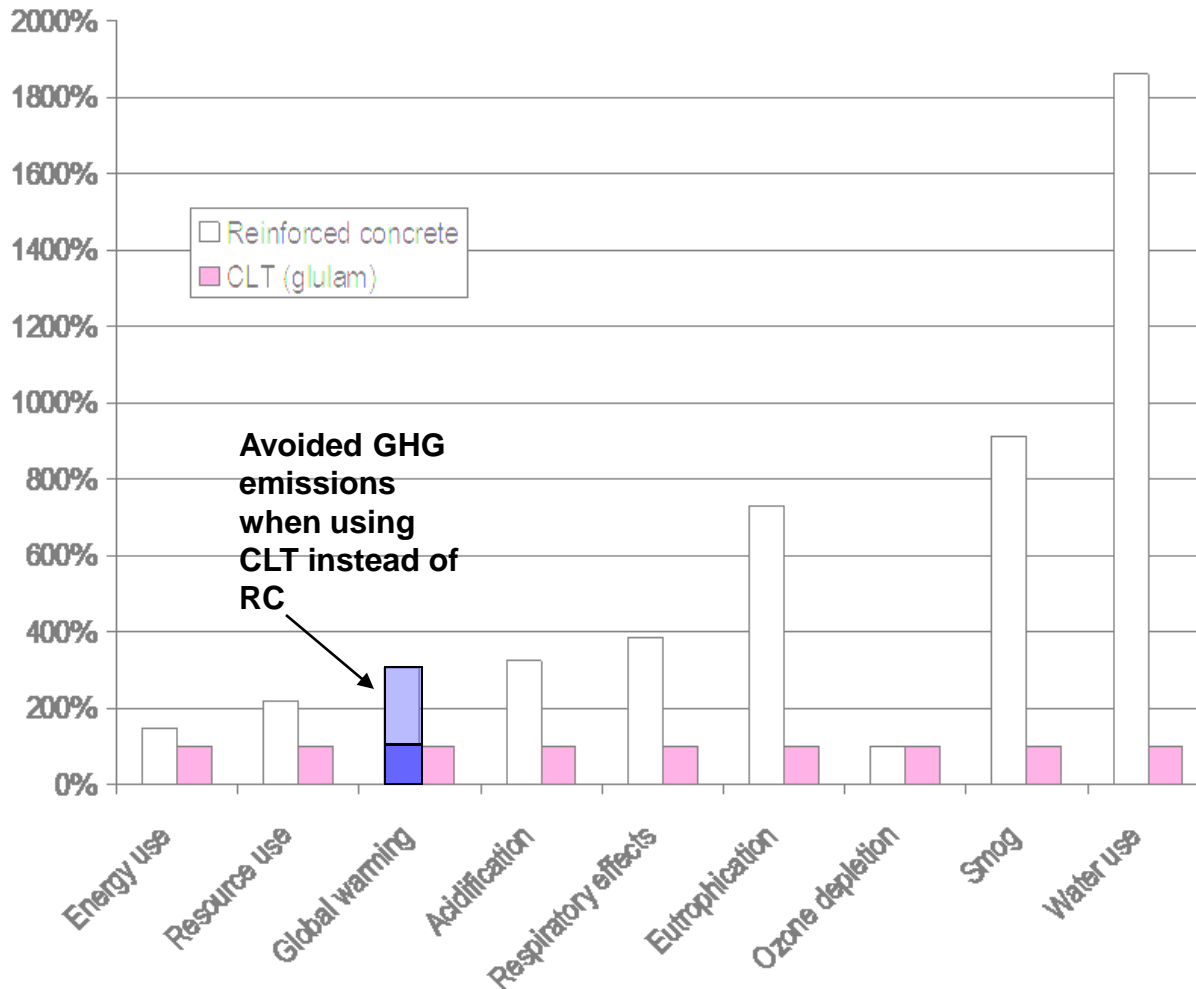
Rough approximation for Stadthaus using material estimates by others and the Athena Impact Estimator software.

Comparison is using glulam as a proxy for CLT.

This graph shows relative results, benchmarked to the CLT building, for several environmental impact categories.

Global warming category does not take a credit for carbon stored in the CLT.

Mid-Rise Comparative Snapshot - Carbon



CLT is environmentally interesting for its carbon profile.

There are two aspects to the carbon story.

First – typical for wood systems – there are substantial avoided greenhouse gas emissions when using wood instead of something else.

Second, carbon in the wood is a long-term pool of greenhouse gas removed from the atmosphere.

Mid-Rise Carbon Estimate

Mass of CO₂ stored (metric tons):	631
Mass of estimated CO₂ avoided (metric tons):	244
TOTAL combined estimated CO₂ effect (metric tons):	875
Equivalent to one year of emissions from this many cars:	167

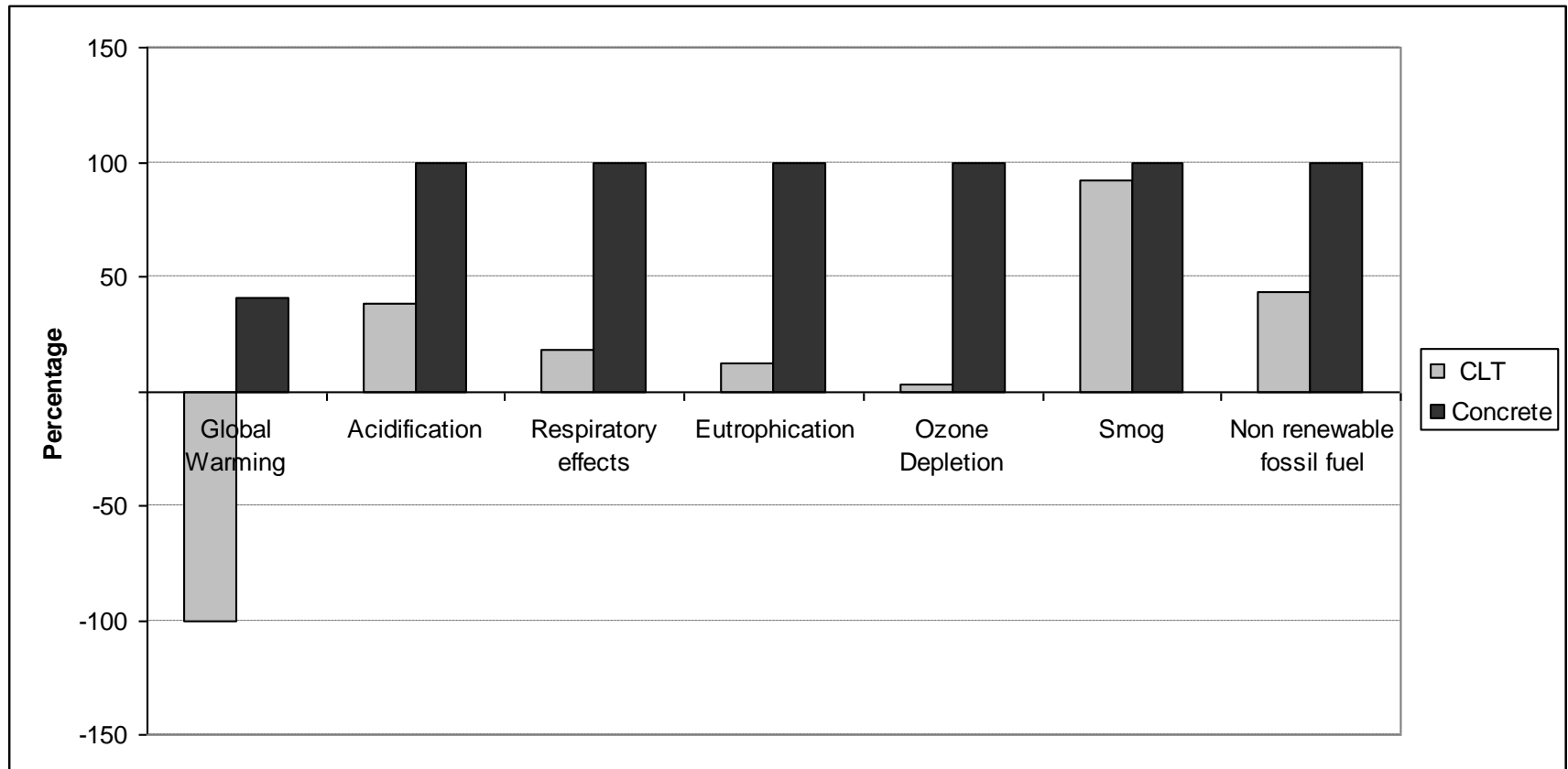
This is the amount of CO₂ taken up by the tree to make the wood used in this building.

This is the difference in embodied CO₂ emissions between CLT and a functionally-equivalent amount of reinforced concrete.

Floor Comparison - Approach

- Started with existing life cycle inventory (LCI) data for Canadian glulam.
- Adjusted this data by modifying wood and adhesive volumes to approximate an LCI for CLT.
- Received functionally-equivalent floor sections for CLT and reinforced concrete. Highly conservative design for CLT (thicker than the concrete floor section).
- Performed cradle-to-building site LCA analysis for 1 m² of CLT and concrete at the design thicknesses. Fasteners and reinforcing steel not included.

Floor Comparison – Results



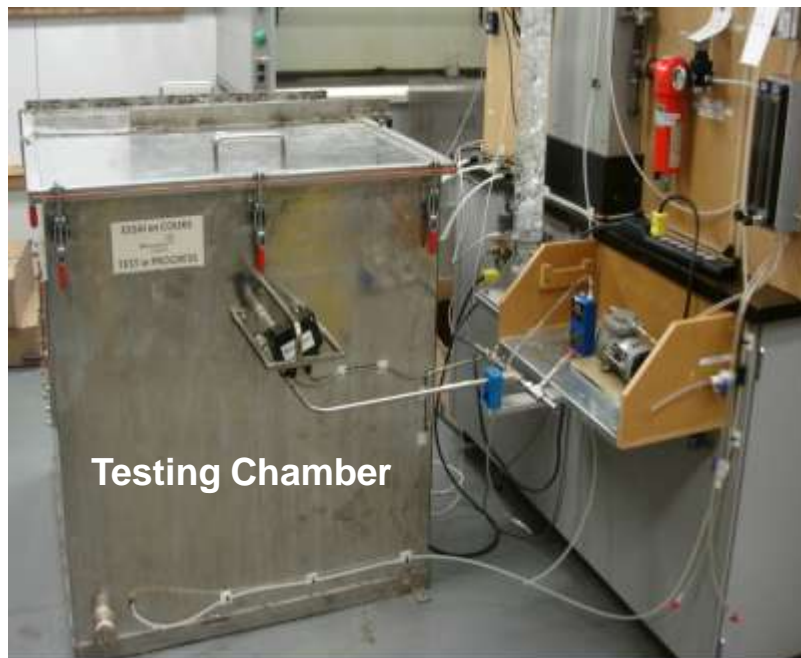
Environmental Footprint - Conclusions

- Rough estimate suggests CLT has a better embodied profile than functionally equivalent concrete systems.
- More data needed for a firm conclusion.
- Potential thermal effects of CLT need investigation.
- Design for deconstruction likely important to address concerns about material consumption.
- Appears to have a sound argument for a carbon credit when substituted for concrete.

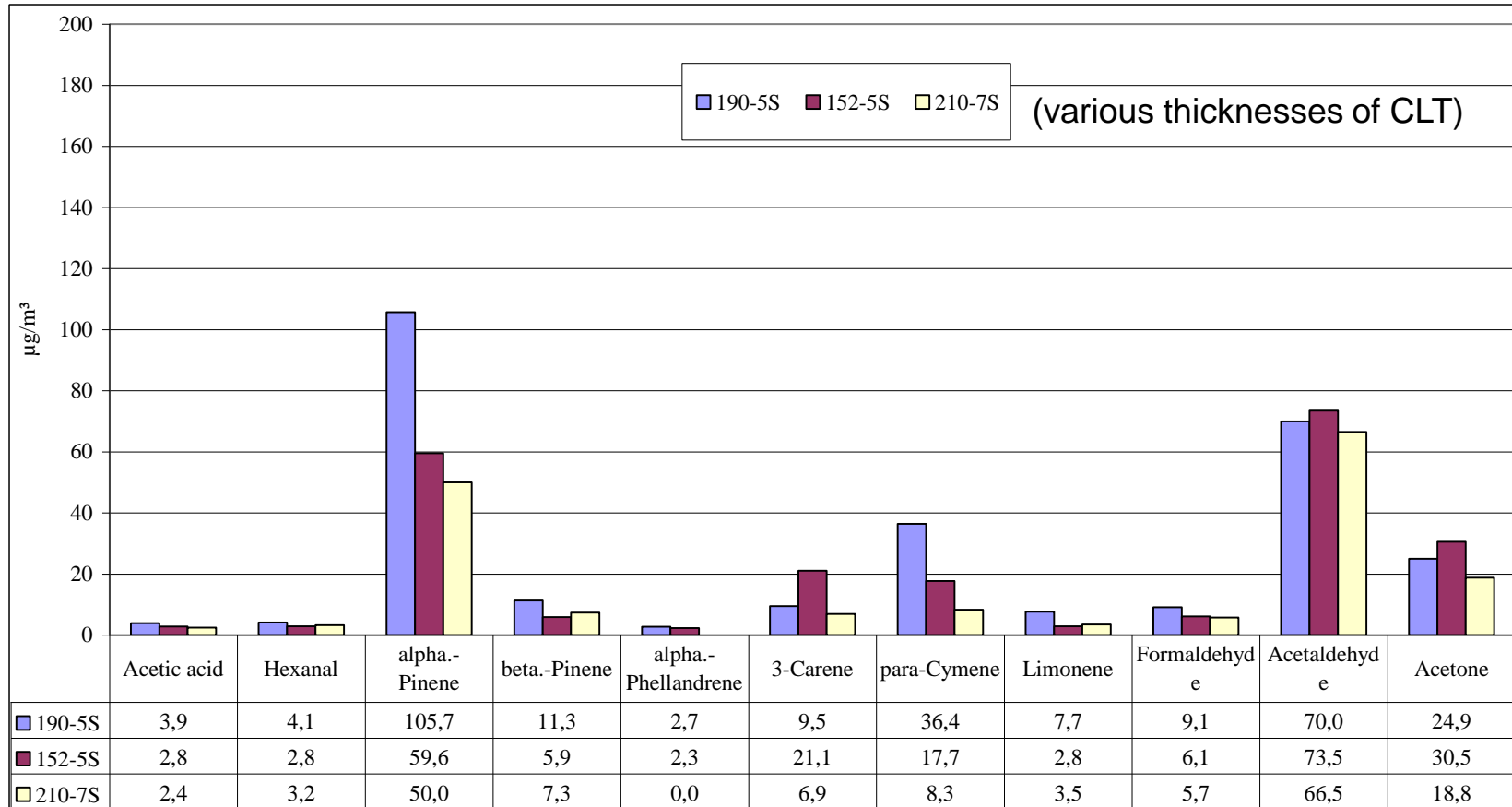
Indoor Air Quality Impact - Method

Volatile organic compounds (VOCs) evaluated according to ASTM D 5116-10 and ANSI/BIFMA M 7.1-2007 standards.

Formaldehyde was evaluated according to NIOSH 3500 method



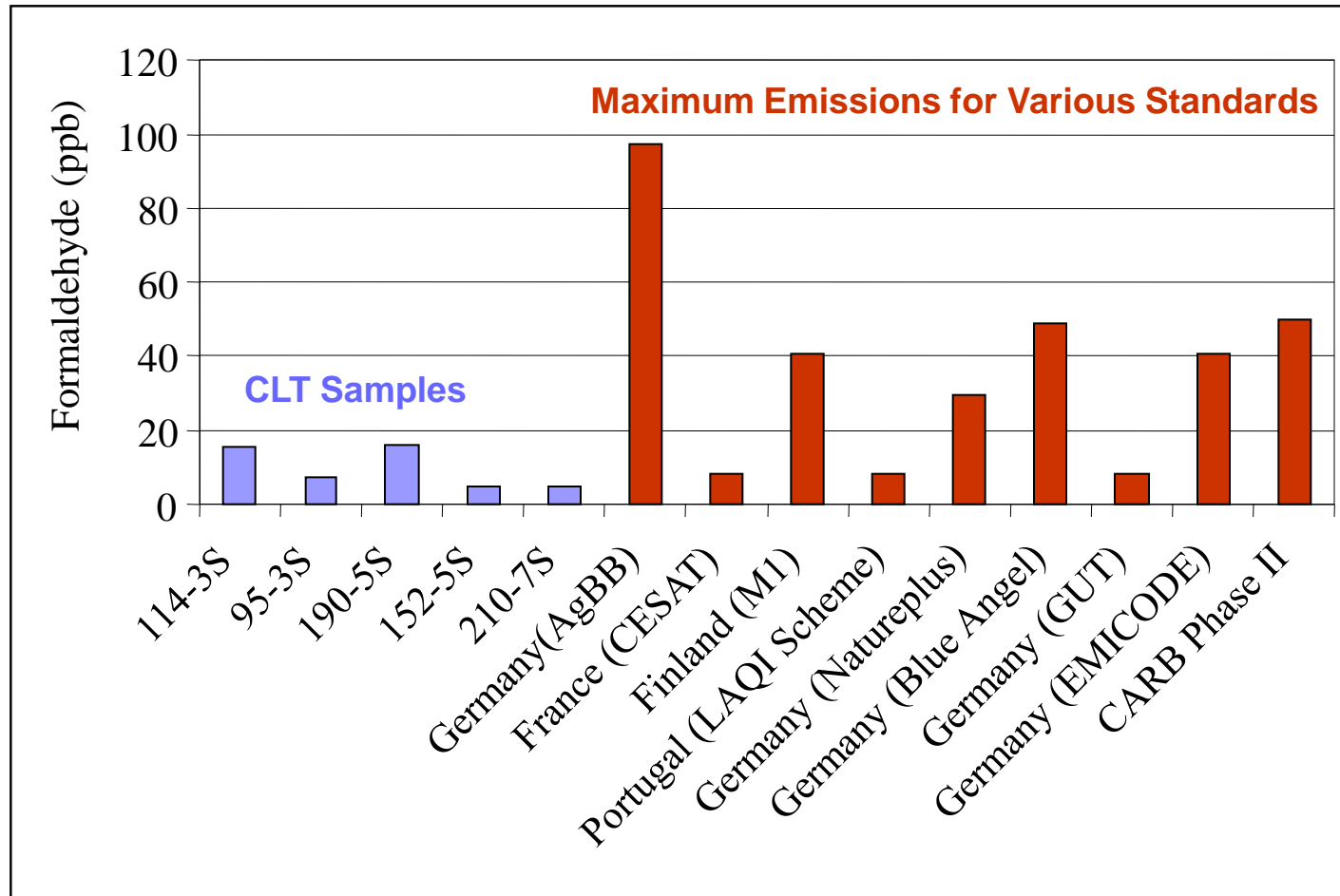
VOC Emissions - Results



VOC emissions as a function of CLT Types

Five different samples in total were tested. No correlation between VOCs and CLT thickness / number of glue lines. All detected VOCs originate with the wood material itself.

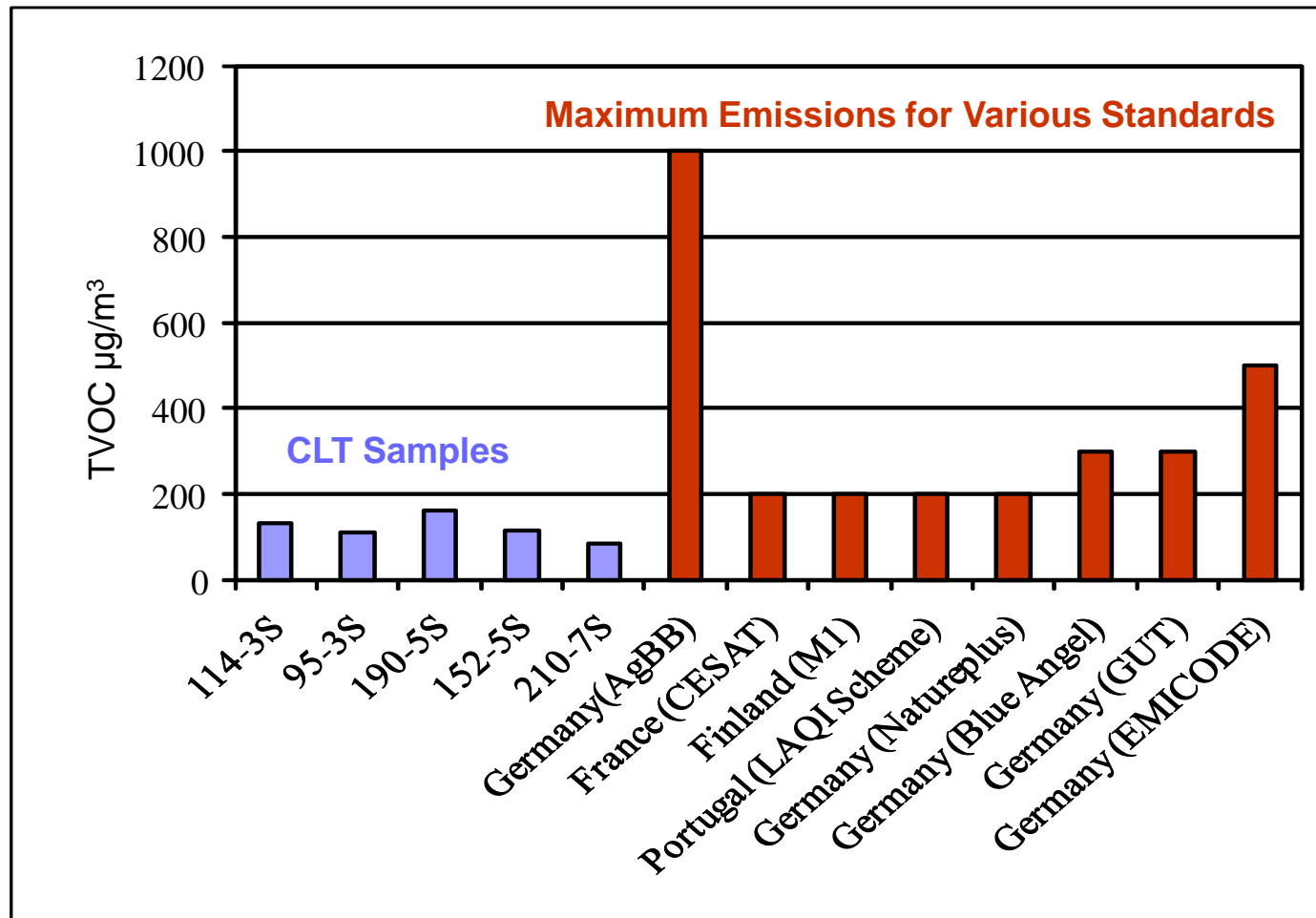
CLT Formaldehyde Emissions vs Standards



CLT 24-hour vs European limits after 28 days sample exposure

The five samples easily pass European standards and the most stringent N. American standard (CARB phase II).

CLT Total VOC Emissions vs Standards



CLT 24-hour TVOC vs some European limits after 28 days sample exposure

CLT Indoor Air Impact

Preliminary Findings-Conclusions

- The CLT TVOC and formaldehyde 24-hour results were generally lower than those set forth by some European emissions labelling systems.
- The European E1 formaldehyde limit (100ppb) was 6 to 20 times higher than the CLT emissions.
- CLT formaldehyde results were 3 to 10 times lower than the most stringent CARB limit set at 50ppb for HWPW-CC.
- Based on these results if confirmed with more data the CLT products could be used indoor with no impact on the air quality.



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