Substitution Benefits of Using Wood

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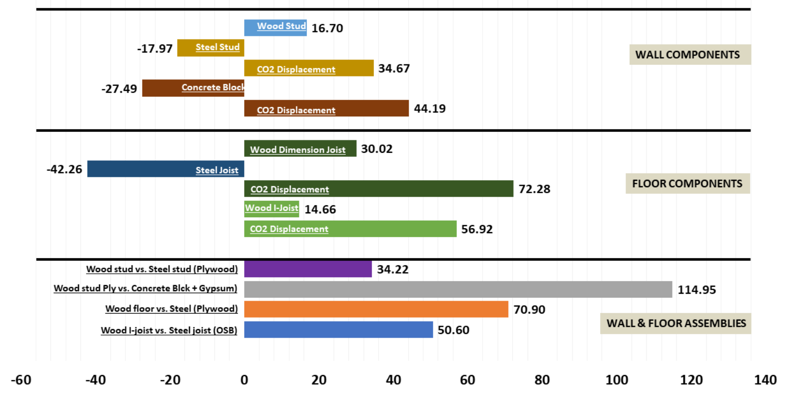
Using wood products as a carbon negative technology

Every product and use has a different carbon impact

Wood growth, harvest, and manufacturing generates less GHG emissions than most other construction materials which require substantial fossil fuel emissions during production. These differences for functionally equivalent materials (e.g., steel stud vs wood stud) are what translates into climate benefits measured in carbon equivalents. They are reported as a substitution value or substitution pool.

Wood is 50% carbon by dry weight. That carbon remains in the product for its lifetime. Combining the substitution factor with the carbon stored in wood products generates a wide range of carbon displacement values as shown for assemblies and components in Figure 1. Effective carbon reduction policies and investments to address these complexities are needed to avoid unintended consequences.

Figure 1: Net Carbon Stored & Carbon Emissions Displaced (kg CO_2/m^2 of Wall or Floor)

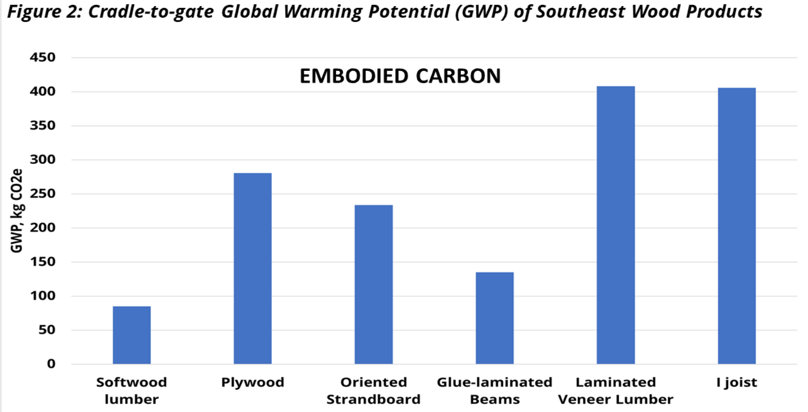


Overview

All manufacturing processes generate environmental impacts. Attributional life cycle assessment (LCA) measure inputs, outputs and emissions from these processes and generate indices of environmental impact, including the emissions of greenhouse gases (GHG) implicated in climate change. Building material manufacturing and construction generates 11% of total global GHG emissions. The global building stock, which primarily uses concrete and steel, is projected to double over the next 40 years. Depending on the application, wood products can substantially reduce the GHG emissions associated with building construction. The accounting is complex as the benefits arise from differences between functionally equivalent materials for three factors:

- Embodied carbon: Figure 2 shows growth, harvesting, and manufacturing emissions in GHG equivalents.
- Carbon storage: Figure 1 shows carbon stored in an inert form in the product itself.
- Substitution: embodied carbon differences between two functionally equivalent products (Figure 1).

Figure 2: Cradle-to-gate Global Warming Potential (GWP) of Southeast Wood Products

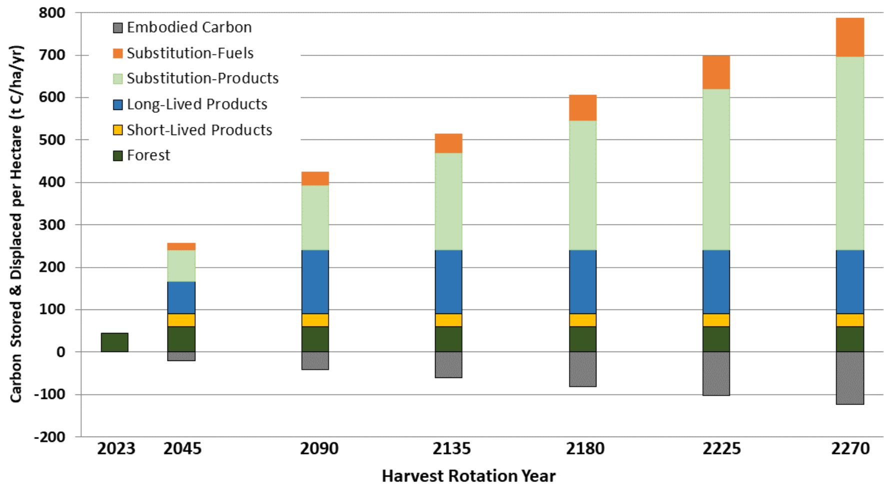


Best Practices for Reducing Carbon Emissions in the Building Sector

- **Where appropriate use carbon negative technologies, including wood in place of fossil fuel intensive materials such as steel and concrete.**
- **Increase the service life of buildings**
- **Increase reuse, recycling, and circularity**
- **Where feasible use local sustainably produced wood sources to avoid long transportation distances**

Carbon Impacts

Figure 3: Carbon Pools in Wall Assembly - Wood Stud vs. Steel Stud

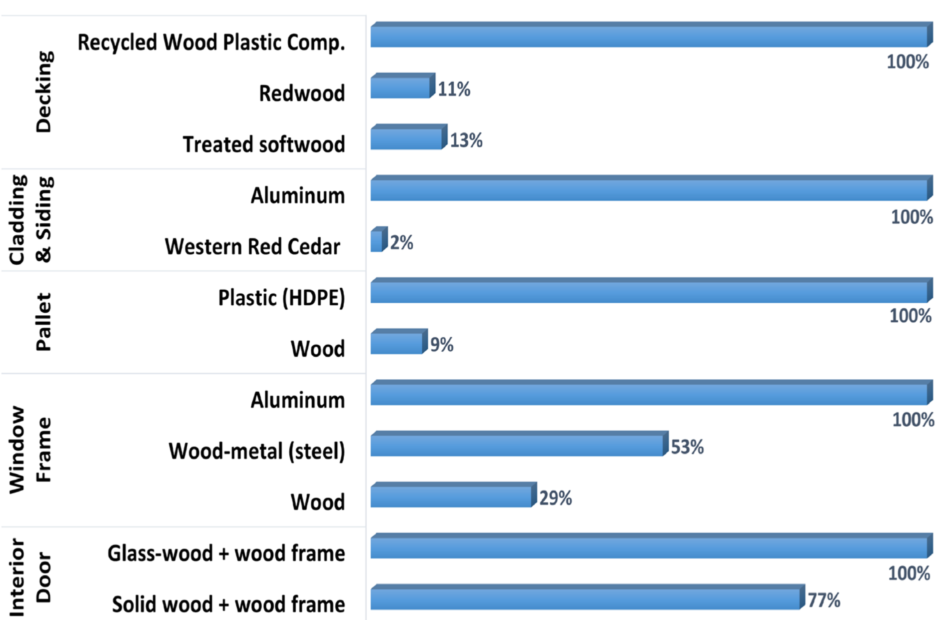


Allocating embodied carbon, stored carbon, and substitution to a sustainably managed forest hectare (Figure 3) shows their relative contributions through time. Embodied carbon for growing and harvesting plus manufacturing emissions (grey bar) are permanent emissions that accumulate with each subsequent harvest. Through forest growth carbon storage in the forest (dark green) increases between harvests. During harvest, some carbon remains in the forest with the remainder allocated to short (yellow) and long-term (blue) products. Short-lived products decay before the next harvest (45 years later). Assuming a 90-yr service life for long-lived products used in wall assemblies' results in constant wood product storage per hectare after the first 90 years. For this example, substitution comes from using biofuels (orange) instead of fossil fuels and using wood studs instead of steel studs (light green) based on their embodied carbon relative to functional equivalents. While wood studs decay, returning their carbon to the atmosphere (here after 90 years), manufacturing emissions and substitution are permanent and therefore accumulate at each harvest. Since fossil fuel carbon comes from fossil fuel reserves that will not be replenished in any meaningful time frame, permanence of substitution benefits and manufacturing emissions cannot be dismissed.

Substitution Choices Matter

Figure 4 shows the relative embodied carbon for functional equivalents across a range of non-structural wood uses. Substitution for these uses reduces fossil fuel emissions from 23-98% depending on the wood product used. Structural wood uses (Figure 1) have lower substitution values but make up a greater mass of the building. Design choices that: 1) account for relative substitution benefit for each functional element, 2) their relative contribution to whole building embodied carbon, 3) aim for longevity in use, and 4) create opportunities for reuse, recycling, and re-manufacturing will determine how buildings integrate circular economy principles.

Figure 4: Embodied Carbon-End-use Substitution Benefit of Wood Products



The Takeaway

- **Forests accumulate carbon storage in trees.**
    - **Harvesting transfers stored carbon from the forest to wood products.**
    - **Sustainably managed forests can repeat this cycle in perpetuity.**
- **Substitution provides permanent leverage for mitigating climate change.**
- **How wood is used, and its longevity in use, are the most significant drivers.**
- **Together these factors make wood products the quintessential carbon negative technology for climate mitigation**

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