Dynamic Life Cycle Carbon and Energy Analysis for Cross-Laminated Timber in the Southeastern United States

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Publisher: IOP Publishing Ltd
Year of Publication: 2020
Format: Journal Article
Material: CLT (Cross-Laminated Timber)
Topic: Energy Performance
Keywords: Life-Cycle Assessment
LCA
Dynamic
Carbon Analysis
Greenhouse gas emissions
Energy Consumption
Cradle-to-Grave
Language: English
Research Status: Complete
Series: Environmental Research Letters

Summary:

Life Cycle Assessment (LCA) has been used to understand the carbon and energy implications of manufacturing and using cross-laminated timber (CLT), an emerging and sustainable alternative to concrete and steel. However, previous LCAs of CLT are static analyses without considering the complex interactions between the CLT manufacturing and forest systems, which are dynamic and largely affected by the variations in forest management, CLT manufacturing, and end-of-life options. This study fills this gap by developing a dynamic life-cycle modeling framework for a cradle-to-grave CLT manufacturing system across 100 years in the Southeastern United States. The framework integrates process-based simulations of CLT manufacturing and forest growth as well as Monte Carlo simulation to address uncertainty. On 1-ha forest land basis, the net greenhouse gas (GHG) emissions ranges from -954 to -1445 metric tonne CO2 eq. for a high forest productivity scenario compared to -609 to -919 for a low forest productivity scenario. All scenarios showed significant GHG emissions from forest residues decay, demonstrating the strong need to consider forest management and their dynamic impacts in LCAs of CLT or other durable wood products (DWP). The results show that using mill residues for energy recovery has lower fossil-based GHG (59%–61% reduction) than selling residues for producing DWP, but increases the net GHG emissions due to the instantaneous release of biogenic carbon in residues. In addition, the results were converted to 1 m3 basis with a cradle-to-gate system boundary to be compared with literature. The results, 113–375 kg CO2 eq./m3 across all scenarios, were consistent with previous studies. Those findings highlight the needs of system-level management to maximize the potential benefits of CLT. This work is an attributional LCA, but the presented results lay a foundation for future consequential LCAs for specific CLT buildings or commercial forest management systems.

Online Access: Free

Resource Link

https://iopscience.iop.org/article/10.1088/1748-9326/abc5e6/meta