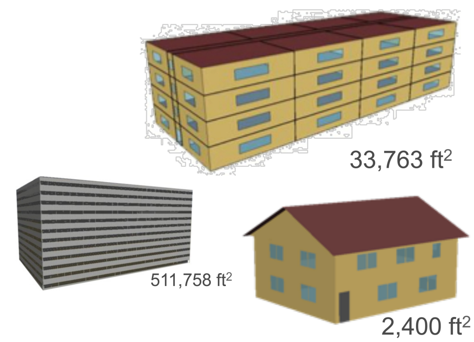
Building Life Cycle Assessment

Quantifying building life cycle environmental impacts

It is important to take a life cycle perspective when evaluating the environmental impacts of buildings and building products

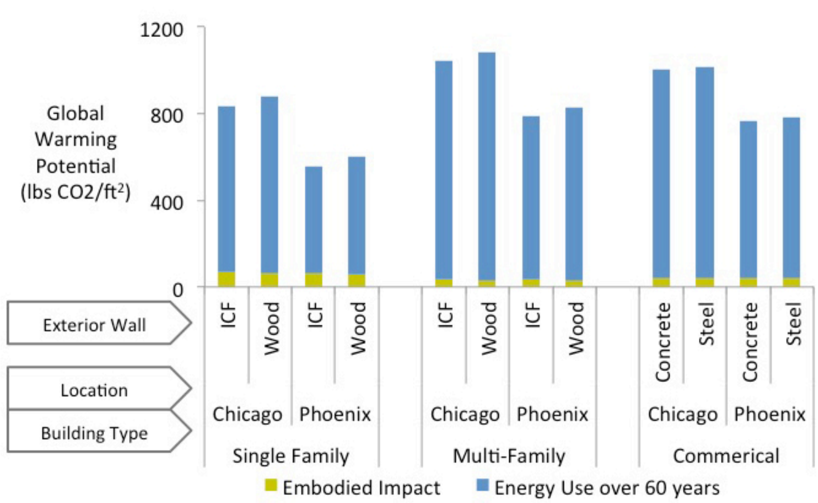
- The environmental impacts of buildings over their lifetimes are determined by several factors including materials, design, construction, use, and demolition.
- An approach called life cycle assessment (LCA) is used to quantify life cycle environmental impacts of buildings.
- LCA can be used to obtain credits in the LEED certification system for assessments of the environmental impacts of individual building products and all products used in buildings. However, it is important that a complete life cycle perspective is used that combines materials (the embodied building impacts) and building use (i.e., energy consumption).
- MIT researchers conducted LCAs of multiple building designs in three building categories: single family, multifamily, and commercial. Two code-compliant designs were analyzed in each category: wood and concrete two-story single-family homes, wood and concrete four-story multifamily buildings, and steel and concrete 12-story commercial buildings.
- Environmental impacts were calculated for one heating climate (Chicago) and a cooling climate (Phoenix) assuming a 60-year building lifetime.



Two code-compliant designs were analyzed in each building category; wood and concrete two-story single-family homes (2,400 sf), wood and concrete four-story multifamily (34,000 sf), steel and concrete 12-story commercial (500,000 sf) buildings.

The use phase dominates the life cycle environmental impact of the buildings studied

- Environmental impacts for buildings are typically divided into embodied impacts, which are associated with the pre-use phase of LCA, when raw materials are harvested and turned into construction materials, transported to the site and assembled into the finished building, and use impacts, which are associated with energy consumption.
- In the buildings studied, the use phase accounted for 88%-98% of the life cycle global warming potential (GWP–a metric that tallies the impacts of greenhouse gas emissions).



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- An extensive review of other published results on residential building LCA confirms that the use phase dominates the life cycle impacts for most buildings studied.

Concrete buildings can have lower life cycle environmental impact

- The concrete buildings studied had:
    - Higher embodied GWP impacts (7%-31%) than comparative designs;
    - Lower use phase GWP impacts (3%-10%) than comparative buildings,
    - Lower life cycle GWP impacts (5%-8%) than comparative buildings.
- Despite concrete's higher embodied impacts, increased energy efficiency can translate into lower total life cycle impacts because the use phase dominance.

There are numerous opportunities to lower environmental impacts in concrete buildings

- Increasing fly ash or other supplementary cementitious material substitution from 10% to 50% in the ICF house reduced its environmental impact by 12% to 14%.
- Moving from a 6-inch to a 4-inch concrete wall is cost-effective, reduces emissions over the lifetime of the wall assembly, and should be considered in regions of the country where a 4-inch walls meets structural requirements.
- Increasing the thickness of the insulation layers flanking the concrete core of ICF construction can have cost effective benefits. Increasing the thickness of insulation from 2.5 inches to 4 inches represents the most cost effective means of increasing the thermal performance of the wall assembly because the increased cost of the insulation is less than the current market price of the carbon saved.

Additional information may be found at: http://cshub.mit.edu/

Publications

Ochsendorf, John; Keith Norford, L; Brown, D; Durschlag, H; Hsu, S.L; Love, A; Santero, N; Swei, O; Webb, A; and Wildnauer, M. "Methods, Impacts, and Opportunities in the Concrete Building Life Cycle." MIT Concrete Sustainability Hub, 2011.

Miller, T. Reed; Gregory, Jeremy; and Kirchain, Randolph. "Critical Issues When Comparing Whole Building & Building Product Environmental Performance." MIT Concrete Sustainability Hub, 2016.

Ghattas, Randa; Gregory, Jeremy; Noori, Mehdi; Miller, T. Reed; Olivetti, Elsa; and Greene, Suzanne. "Life Cycle Assessment for Residential Buildings: A Literature Review and Gap Analysis." MIT Concrete Sustainability Hub, Revised 2016.

Ghattas, Randa; Gregory, Jeremy; Miller, T. Reed. and Kirchain, Randolph. "The decision-making process in the design of residential structures," MIT Concrete Sustainability Hub, March 2015.

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