Life Cycle Assessment of Concrete Buildings

1.0 AIA-CES HSW LU
Course Number: LCA101

BUILD WITH STRENGTH

NRMCA®

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- Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Course Description

Concrete offers several environmental benefits that can help reduce the overall impact of a building. For example, the production of concrete is resource efficient and the ingredients require little processing. Most materials for concrete are acquired and manufactured locally which minimizes transportation energy and associated greenhouse gas emissions. Concrete incorporates recycled industrial byproducts such as SCMs which helps reduce embodied energy, carbon footprint and landfill disposal. Concrete has a long service life, thereby decreasing reconstruction, repair and maintenance and associated environmental impacts. Most importantly, because of concrete's thermal mass, concrete buildings can be extremely energy efficient. From a life cycle perspective, concrete buildings perform well when compared to steel- and wood-frame buildings. As a result, concrete buildings may be a lower carbon footprint option over the entire life cycle of a structure.

Learning Objectives

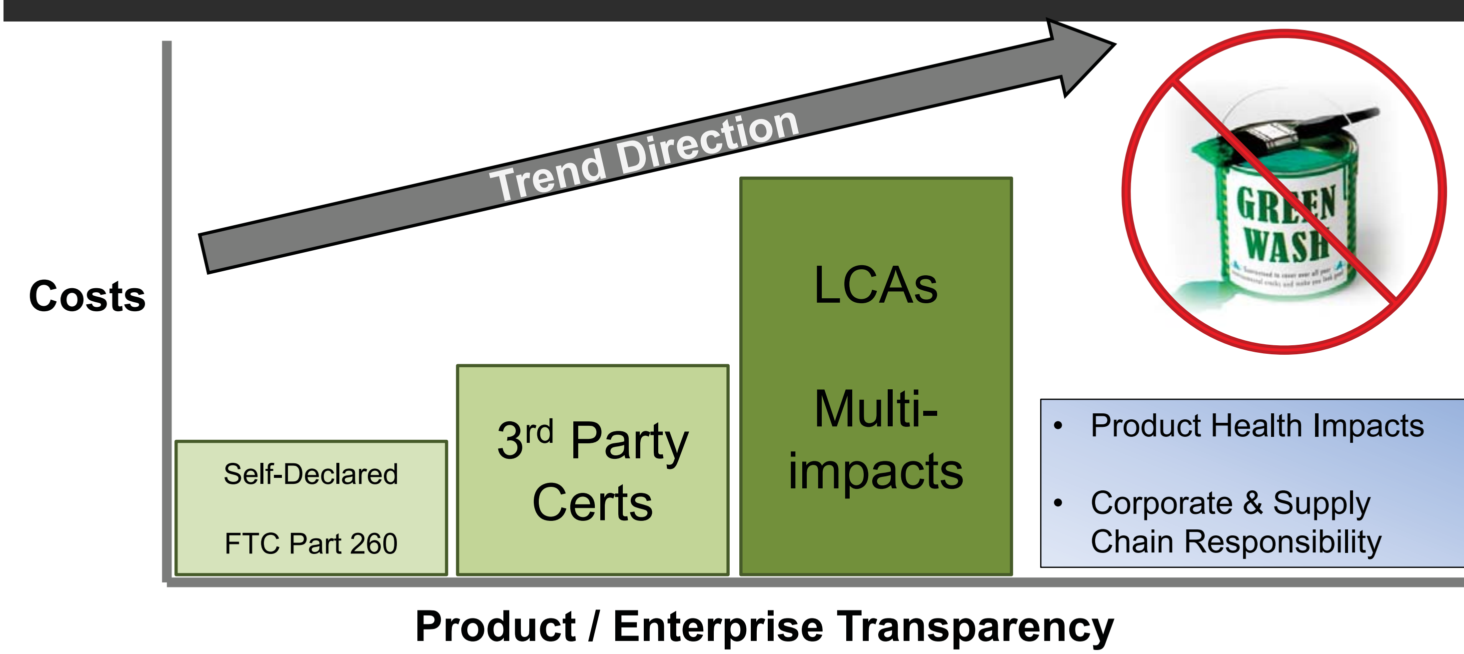
At the end of this session, you should be able to:

- Understand life cycle assessment (LCA) and how it can be used to help measure and reduce the environmental impacts of a building.
- Explore LCA and how it is used in the green building standards.
- Review examples of how LCA software tools can be used to compare environmental impacts buildings.
- Recognize how concrete can reduce the environmental impacts of a building.

Life Cycle Assessment of Concrete Buildings

AIA-CEU: LCA101 1 LU|HSW

Validating Environmental Claims



Life Cycle Assessment

An objective process that:

- investigates and evaluates all stages of product, process, or service
- identifies and measures energy and materials used (inputs) and wastes released (outputs)
- assesses the impact of those inputs/outputs to the environment, and
- evaluates opportunities to affect environmental improvements
- basis to create EPDS

http://www.coldstreamconsulting.com/life-cycle-analysis

Where LCA is Cited – Business Drivers

- Green Globes
- Living Building Challenge
- International green Construction Code (IgCC)
- CalGreen

LEED v4

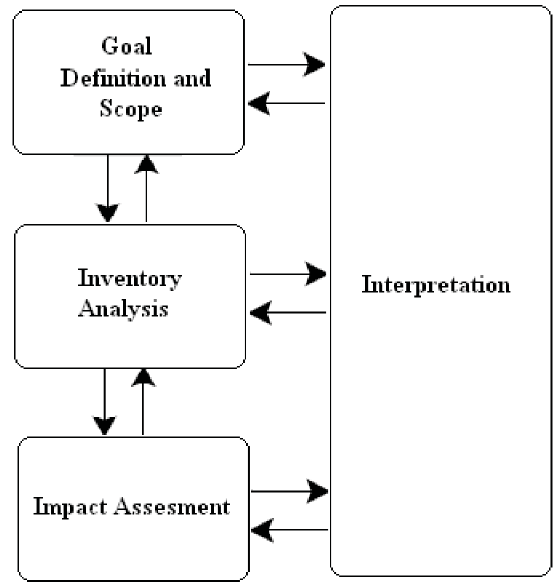
MATERIALS & RESOURCES		POSSIBLE 13
MRp1	Storage and collection of recyclables	REQ
MRp2	Construction and demolition waste management planning	REQ
MRC1	Building life-cycle impact reduction	5
MRc2	Building product disclosure and optimization – environmental product declarations	2
MRc3	Building product disclosure and optimization – sourcing of raw materials	2
MRc4	Building product disclosure and optimization – material ingredients	2
MRc5	Construction and demolition waste management	2

International Organization for Standardization (ISO)

- ISO 14000 environmental management standards
- The procedures of life cycle assessment (LCA)
  - ISO 14040
  - defines four distinct phases

Four Phases of Performing LCA

1. Goal and Scope (ISO 14040)
2. Life Cycle Inventory Analysis (ISO 14041)
3. Life Cycle Impact Assessment (ISO 14042)
4. Interpretation (ISO 14043)

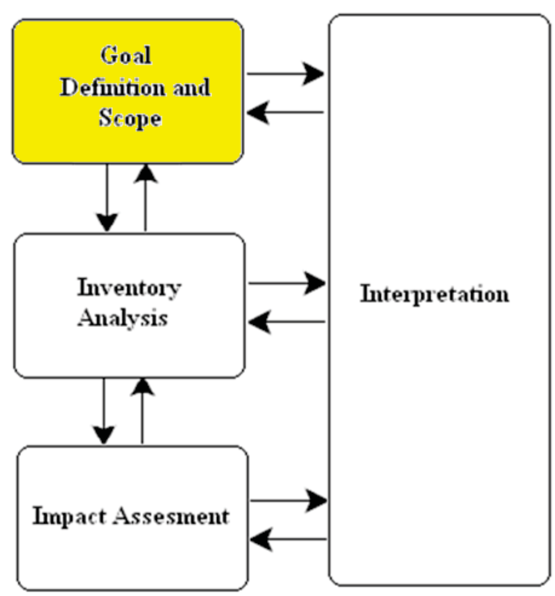


Source: ISO (1997)

Phase 1: Goal Definition & Scope

Goal Definition and scoping defines the purpose and method

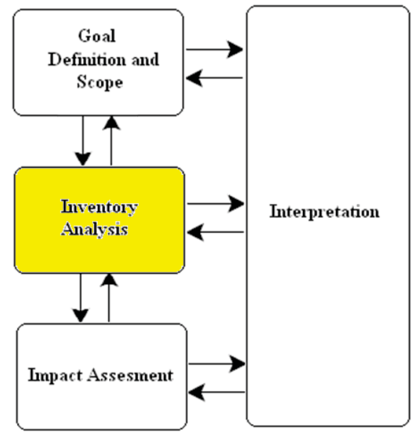
1. Define the goal(s) of the project
2. Scope of the study:
   - establish scope of the assessment
   - parties involved and audience
   - Functional use, functional unit and reference flow
   - system boundaries, i.e., structure & enclosure
   - Impact categories



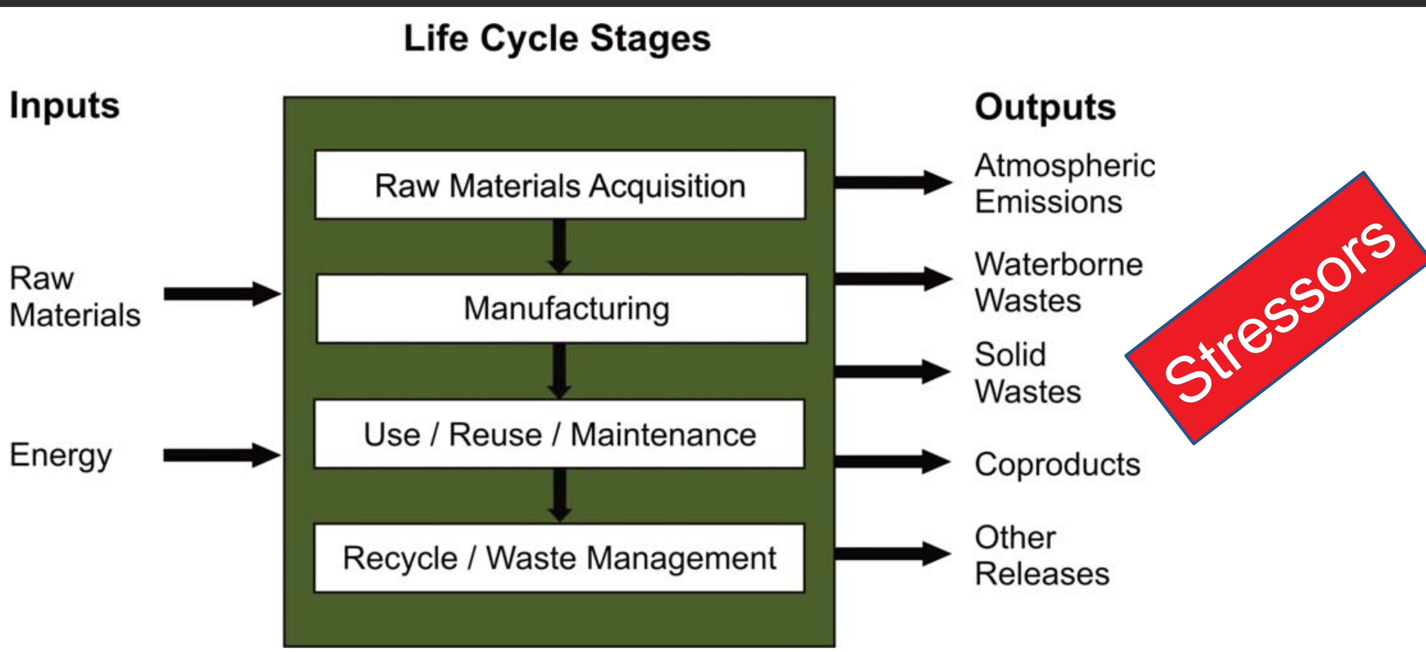
Phase 2: Inventory Analysis

In this phase, all relevant input/output data is collected and organized

1. Develop a flow diagram of the processes being evaluated
2. Develop a plan, categorize and collect data
3. Validate data
4. Evaluate and report results

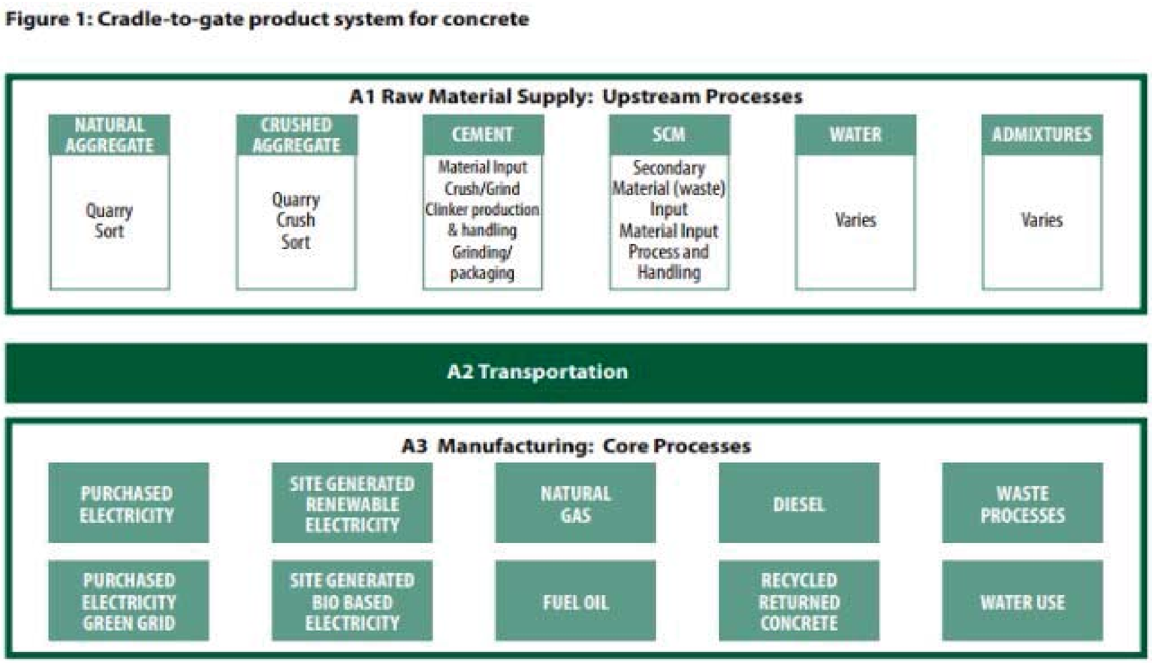


Product System - Inventory Analysis



Source: EPA (2003)

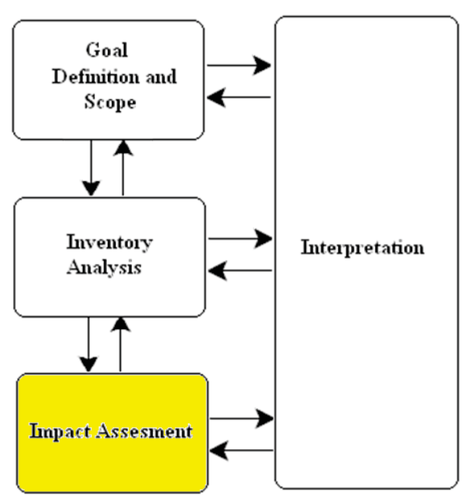
Example of RM Concrete LCI Data Sources



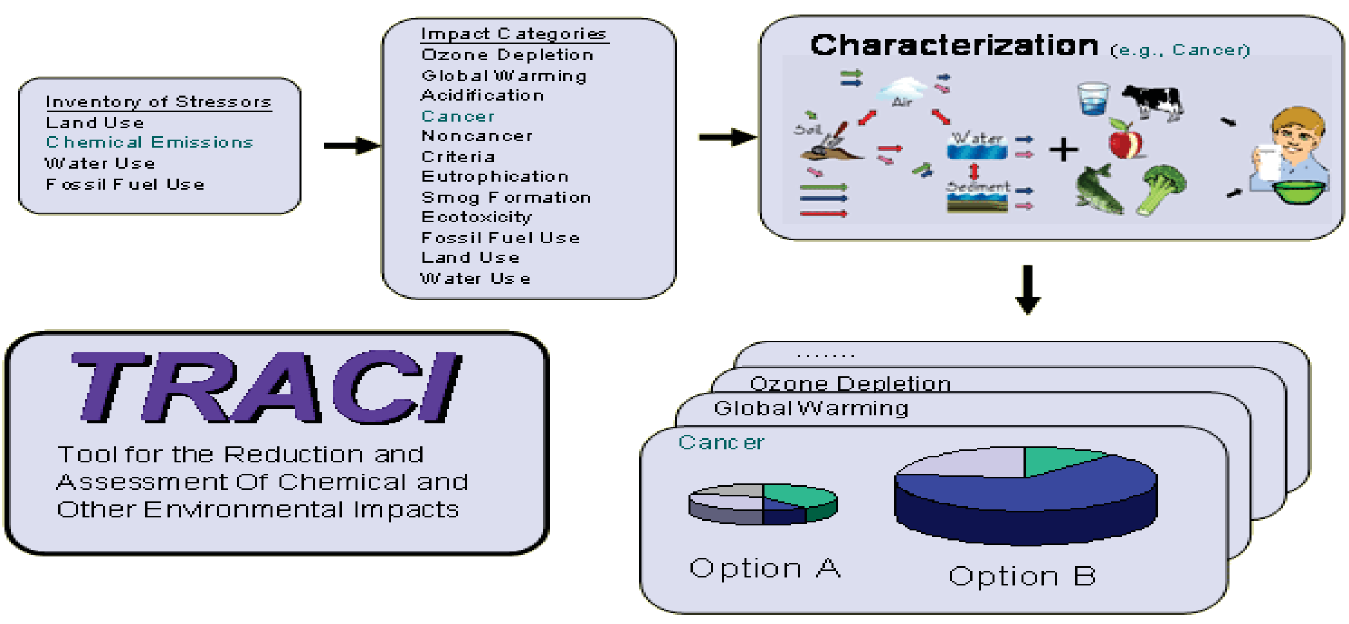
Phase 3: Impact Analysis

Model Impact Analysis evaluates potential human health and environmental impacts

1. **Selection of Impact Categories**
2. **Classification**
3. **Characterization**
4. Normalization
5. Grouping
6. Weighting
7. Evaluating and Reporting LCIA Results



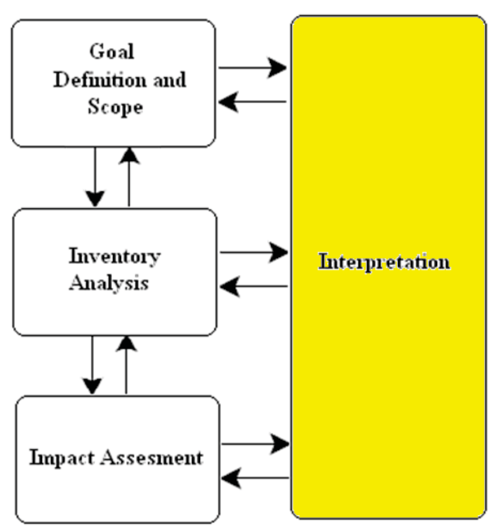
TRACI – U.S. EPA



Phase 4: Interpretation

Systematic technique to identify, quantify, check, and evaluate information from the results of the LCI and the LCIA

1. Identification of the Significant Issues Based on the Inventory Analysis and Impact Analysis.
2. Evaluation which Considers Completeness, Sensitivity, and Consistency Checks.
3. Conclusions, Recommendations, and reporting.



Desired Results of LCA

- A systematic evaluation of the environmental consequences
- Quantification of environmental releases
- Comparison of the health and ecological impacts between two or more rival products/processes
- Assessment of the human and ecological effects of material consumption
- Analyze the environmental trade-offs

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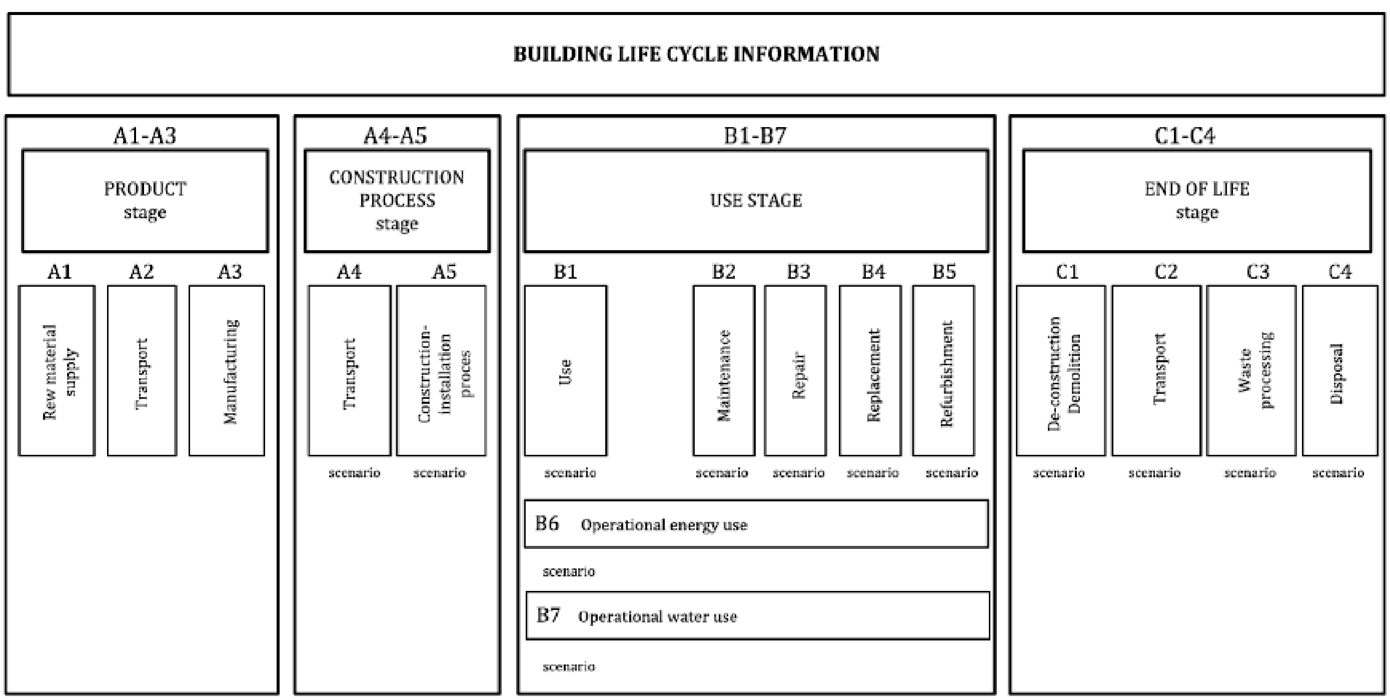
Whole Building LCA : Beyond Embodied



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LCA Software Tools

- Add-up EPDs
- Athena
  - – free
- Tally
  - – link to Revit
- One Click
  - – entering market

LEED v4 DRIVING TRANSPARENCY

MRc1: Building Life Cycle Impact Reduction

Option 4: Whole Building LCA

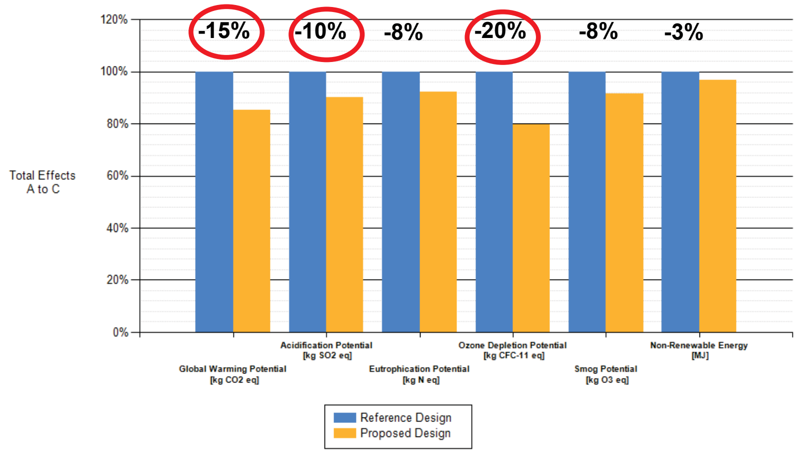
- Structure & enclosure
- Reduction of 10% from baseline building in 3 of 6 impacts
  - GWP of CO_2 (Required)
  - Ozone depletion (CFC)
  - Acidification (land/water)
  - Eutrophication (phosphates)
  - Tropospheric Ozone (SOx,NOx)
  - Non renewable energy
- *At least* 60 year life span
- Embodied (mostly)

Research examples of WBLCA

- Ex. 1: Concrete structure complying with LEED (simplified)
  - reducing impact categories by modifying SCMs
- Ex. 2: MIT Research for Commercial building
  - reducing **GWP** concrete v. steel
- Ex. 3: MIT Research for Single and MF residential buildings
  - reducing **GWP** concrete v. wood

Example 1: Whole Bldg LCA Credit

Athena Sustainable Materials Institute



- 5 Story Building
- Concrete Frame
- Reference Building
  - 4000 psi concrete
  - 9% fly ash
- Proposed Building
  - 4000 psi concrete
  - 35% fly ash

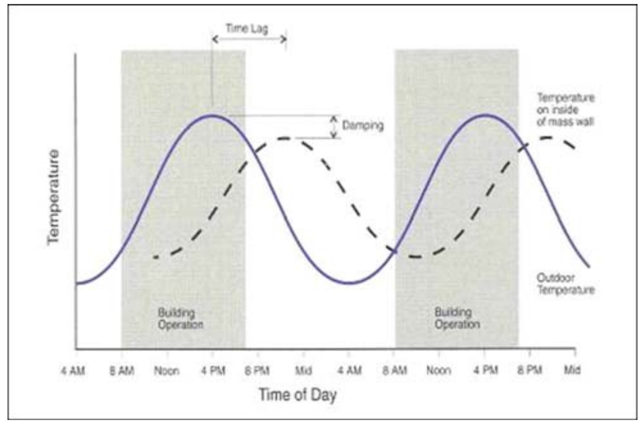
WB LCA Credit requirement with concrete alone!

Example 1a: WBLCA Credit

- Capitol Tower, Houston, TX.
- 35-story, 750,000 square foot, Class A office building
- concrete pan formed beams with post-tensioned girders, a mat foundation and concrete core/shear walls.
- LEED Platinum
- met the life cycle assessment (LCA) credit in LEED v4
  - using high volume supplementary cementitious material mixes for the concrete.

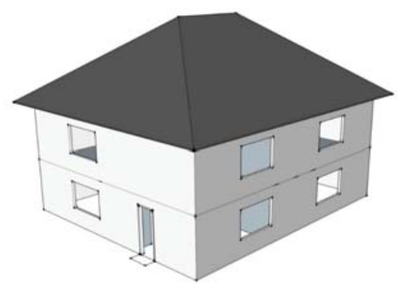
Concrete Attributes

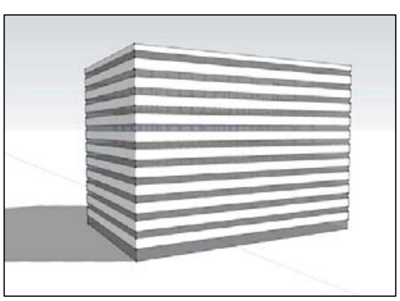
- Local material
  - Raw materials and production
- Minimal processing
  - Efficient operations
- Uses industrial wastes (by-products)
  - Fly ash, slag
- Resilient / long service life
- Recyclable
- Thermal mass
  - Reduces energy consumption during building operations



MIT Research

- Ex. 2, Commercial
- Ex. 3, Residential
  - Single & Multi-family





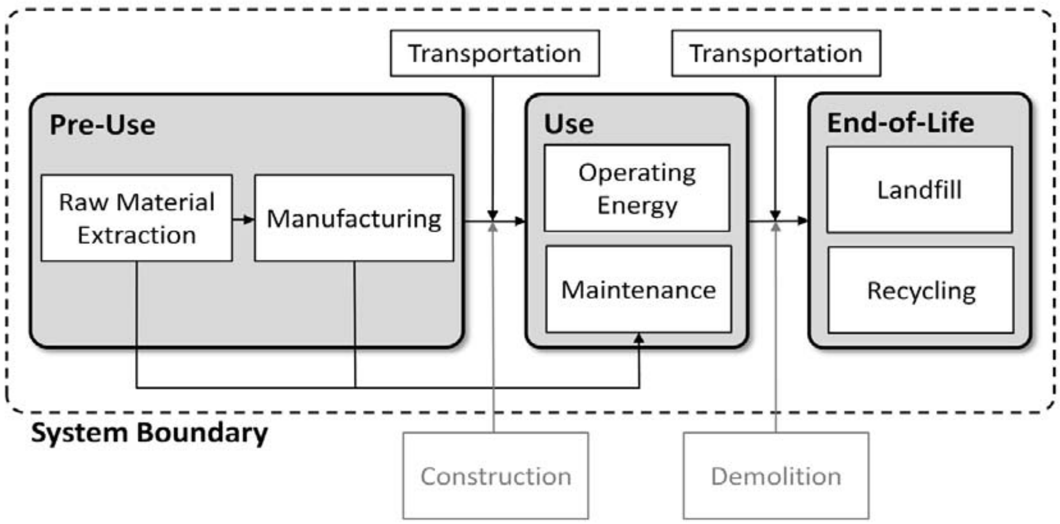
MIT Research: Methodology

- Operating energy for 60-year life cycle
- Two cities having different climates
- Global warming potential (CO_2e) quantified for several purposes
  - Benchmarking emissions of current construction practices
  - Comparing impacts of concrete versus other materials
  - Understand relative magnitude of relative impacts of different life cycle phases

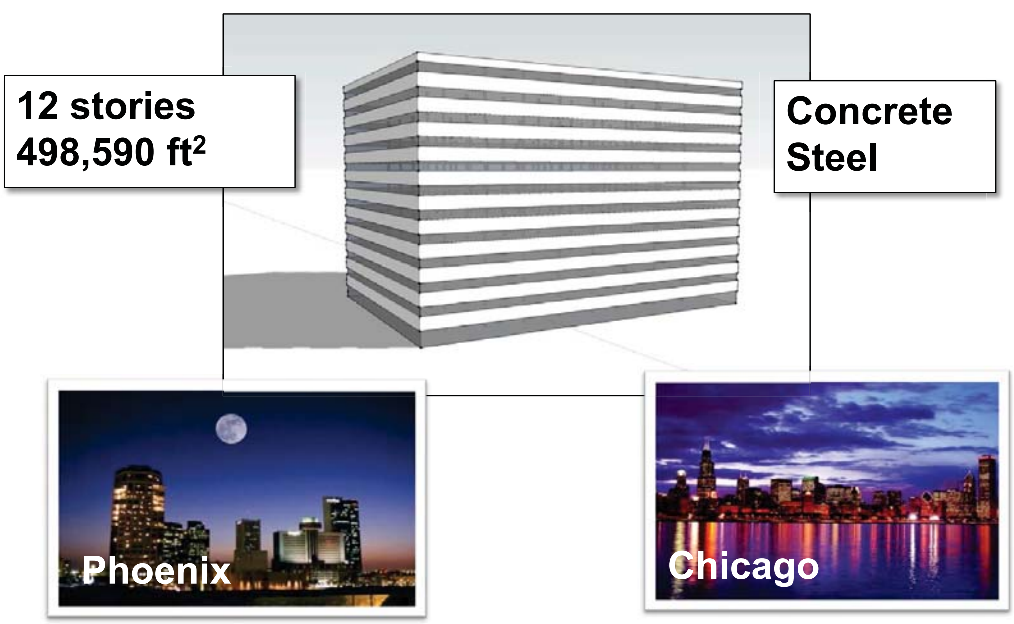
MIT Research: Methodology

- GaBi software to conduct the LCA
- EnergyPlus for energy simulations
  - however, BAHSP for single family

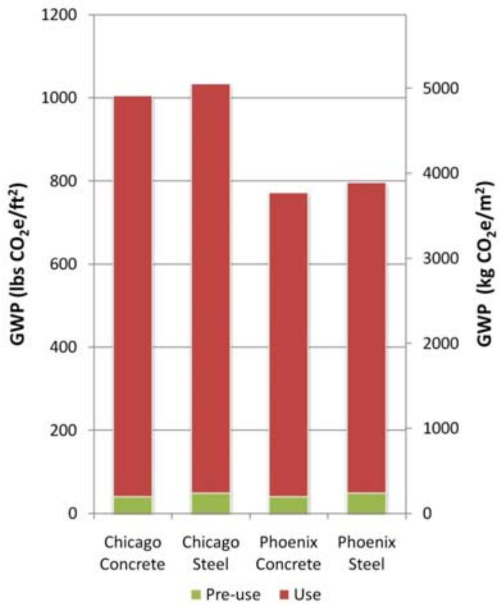
MIT Research: Methodology

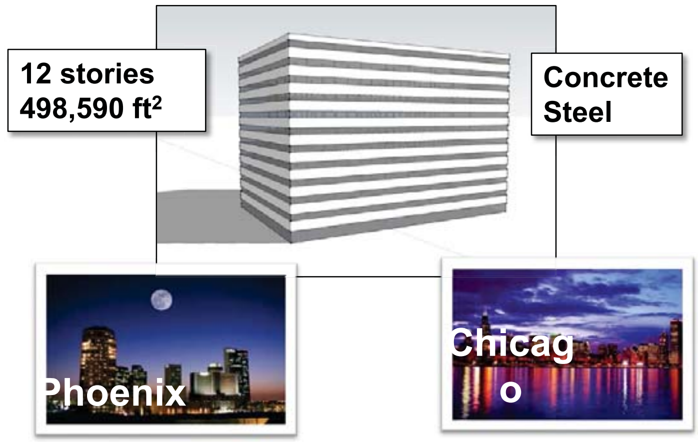


Example 2: MIT Research



Example 2: Concrete Frame vs. Steel Frame

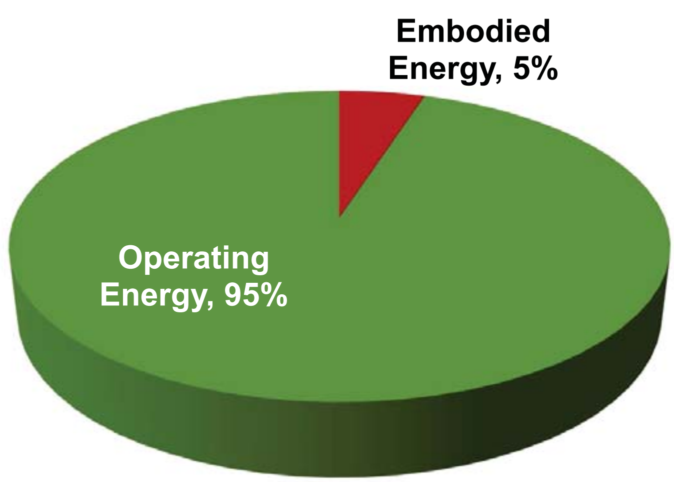




Ochsendorf, J., et al., *Methods, Impacts, and Opportunities in the Concrete Building Life Cycle,* Massachusetts Institute of Technology Concrete Sustainability Hub, Cambridge, MA, 2011.

Example 2: Life Cycle Impacts

Global Warming Potential



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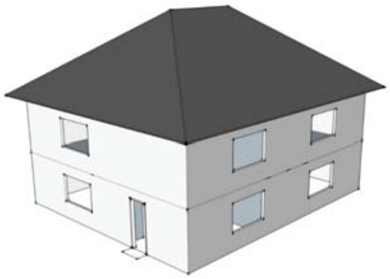
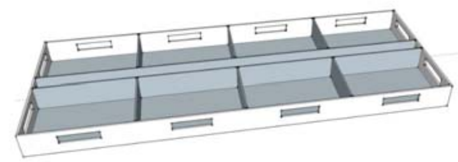
Example 3: Single & Multifamily Building

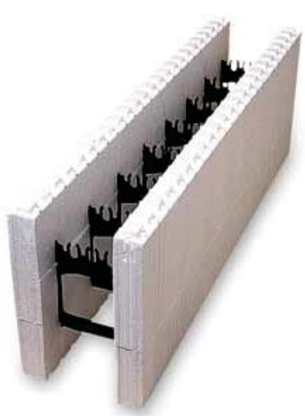


2 stories
2,400 ft^2

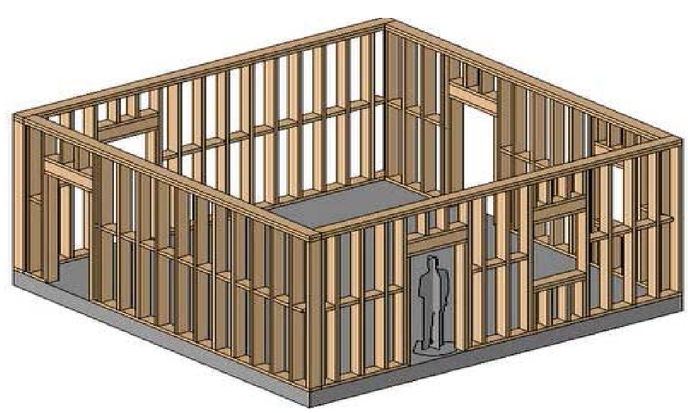
4 stories
33,763 ft^2



Example 3: Structural Systems Considered

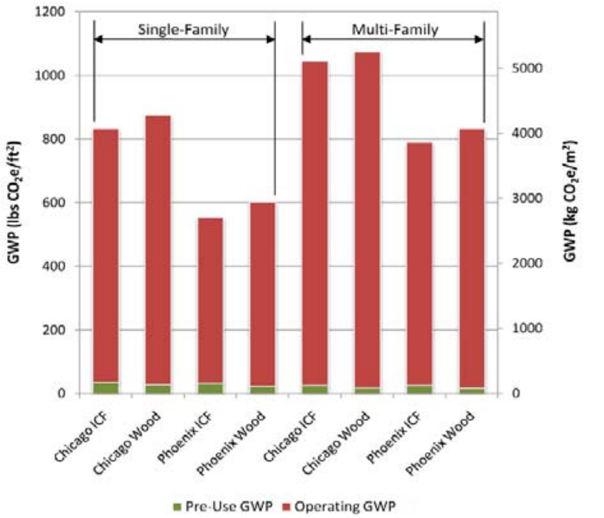


Insulated Concrete Forms (ICF)



Traditional Wood Framing

Example 3: Residential Results



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Summary

- Market trends are pushing robust disclosure
  - LEED, IgCC, Green Globes, LBC
- LCA quantifies environmental impact
- Decades of operational performance dominates over embodied impacts
- When considering a long life of a building…
  - Concrete attributes can lower env impacts
- **However**, it depends on each project
  - *Quantifying Environmental Impacts of Structural Material Choices Using LCA: A Case Study*. D. Davies, L. Johnson, B. Doepker, M. Hedlund

Thank You

?? Questions ??

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