

# Using Life Cycle Assessment for the Design Sustainable Built Environments & Complex Systems

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Presented by:

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Assistant Professor

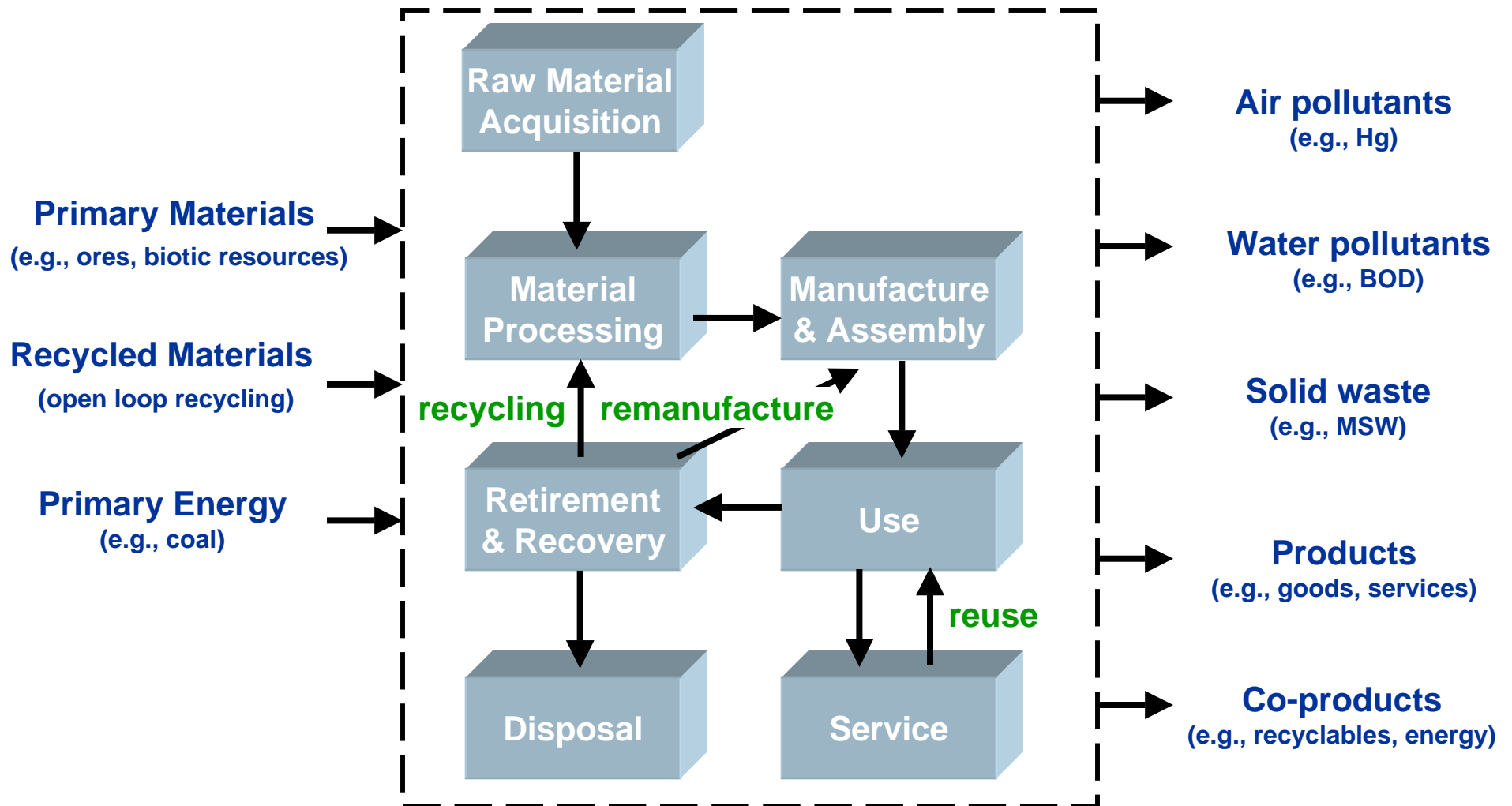
Stanford Civil & Environmental Engineering

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**CIFE TAC Meeting**

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# Overview of Life Cycle Assessment



Processes and products are separated in time and space

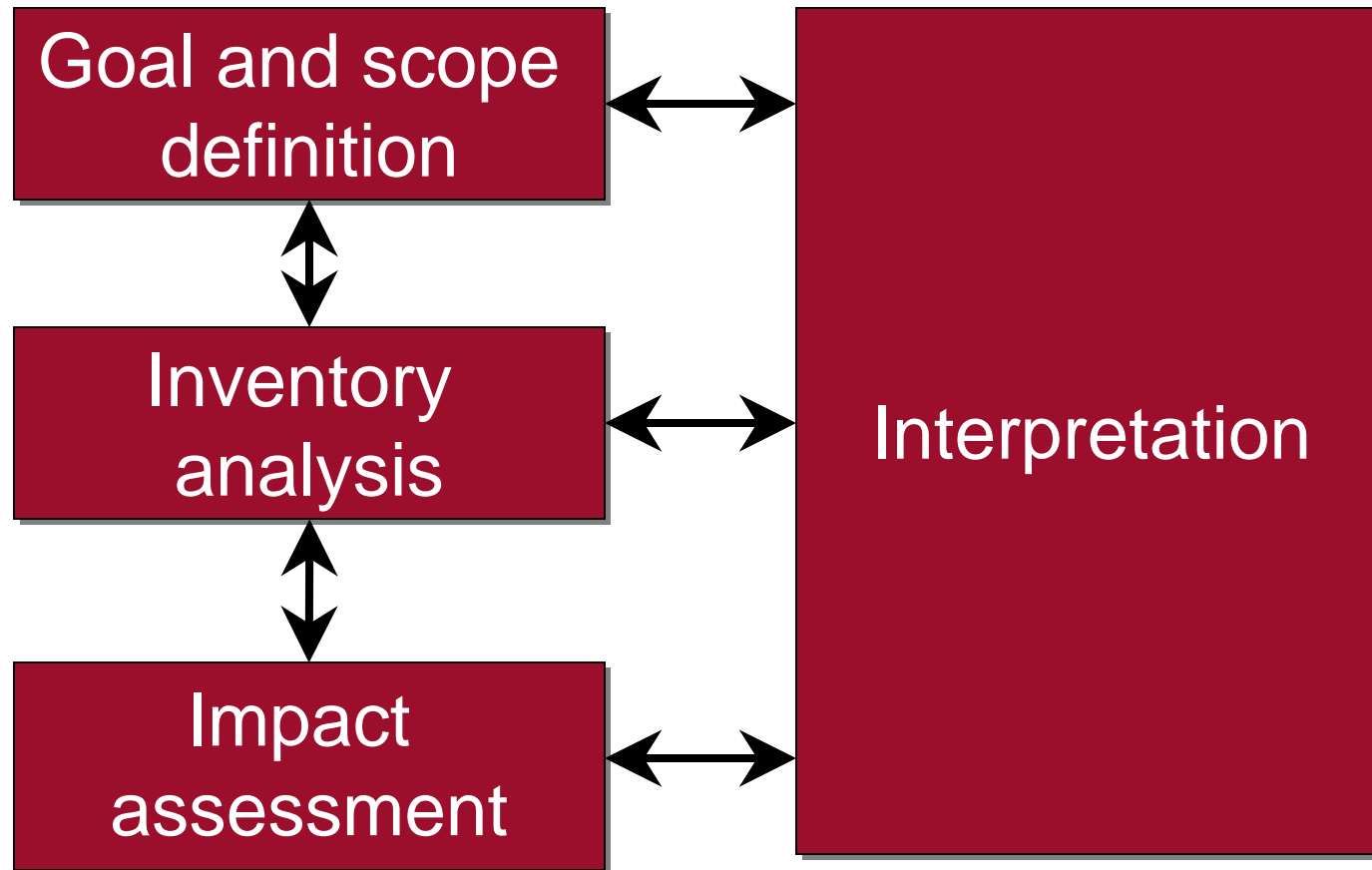
# LCA Standards

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- ISO: International Organization for Standardization
- LCA standards are voluntary
- Part of 14000 Environmental Management Series
- LCA Standards:
  - 14040 Principles and Framework
  - 14041 Goal and Scope Definition and Inventory Analysis
  - 14042 Impact Assessment
  - 14043 Interpretation
- 14020 series: Environmental Labeling

# LCA Requirements

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# Step 1: Goal & Scope

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- Goal of the study
  - State the intended application
  - Identify the intended audience
- Scope of the study
  - Function and functional unit
  - System boundaries
  - Data requirements/assumptions/limitations
  - Critical review and report format

# Step 2: Life Cycle Inventory

Appendix B: Environmental burdens associated with generating 1 MJe electricity in the United States in 2000 [based on generation] (cont'd)

				SPP	WSCC
Butadiene				1.32E-07	4.31E-08
Butane				4.63E-04	4.64E-04
Cadmium				6.30E-06	2.84E-06
Calcium				6.29E-08	2.84E-08
Carbon dioxide (biomass)				9.33E-05	1.17E-03
Carbon dioxide (fossil)	Butadiene	g	6.08E-08	2.60E+02	1.35E+02
Carbon disulfide	Butane	g	3.18E-04	7.28E-06	2.98E-06
Carbon monoxide	Cadmium	g	4.31E-06	8.22E-02	4.76E-02
Chlorides	Calcium	g	1.25E-07	1.54E-05	1.96E-05
Chlorine	Carbon dioxide (biomass)	g	2.97E-04	2.14E-09	1.67E-09
Chlorobenzene	Carbon dioxide (fossil)	g	1.83E+02	3.92E-07	1.60E-07
Chloroform	Carbon disulfide	g	4.46E-06	1.23E-06	5.04E-07
Chromium (Cr III, Cr VI)	Carbon monoxide	g	5.10E-02	3.30E-06	1.35E-06
Chrysene	Chlorides	g	8.78E-05	1.56E-04	6.90E-05
Cobalt	Chlorine	g	1.23E-09	7.20E-09	3.09E-09
Copper	Chloroacetophenone	g	2.41E-07	5.90E-06	2.66E-06
Cumene				2.87E-07	3.07E-07
Cyanide				2.97E-07	1.21E-07
Di(2-ethylhexyl)phthalate				1.40E-04	5.73E-05
Dibenzo(a,h)anthracene				4.09E-06	1.67E-06
Dichlorobenzene				2.24E-09	9.14E-10
Dimethyl benzantracene				2.64E-07	2.65E-07
Dimethyl sulfate				3.51E-09	3.53E-09
Dinitrotoluene				2.69E-06	1.10E-06
Dioxins (unspecified)				1.57E-08	6.42E-09
Diphenyl				1.09E-09	4.98E-10
Ethane				9.51E-08	3.90E-08
Ethyl benzene				6.83E-04	6.85E-04
Ethyl chloride				5.27E-06	2.16E-06
Ethylene dibromide				2.35E-06	9.60E-07
Ethylene dichloride				6.73E-08	2.75E-08
Fluoranthene				2.25E-06	9.14E-07
Fluorene				6.61E-08	2.53E-08
				1.50E-07	5.37E-08

Kim. S. and Dale, B. (2005)

# Life Cycle Impact Assessment

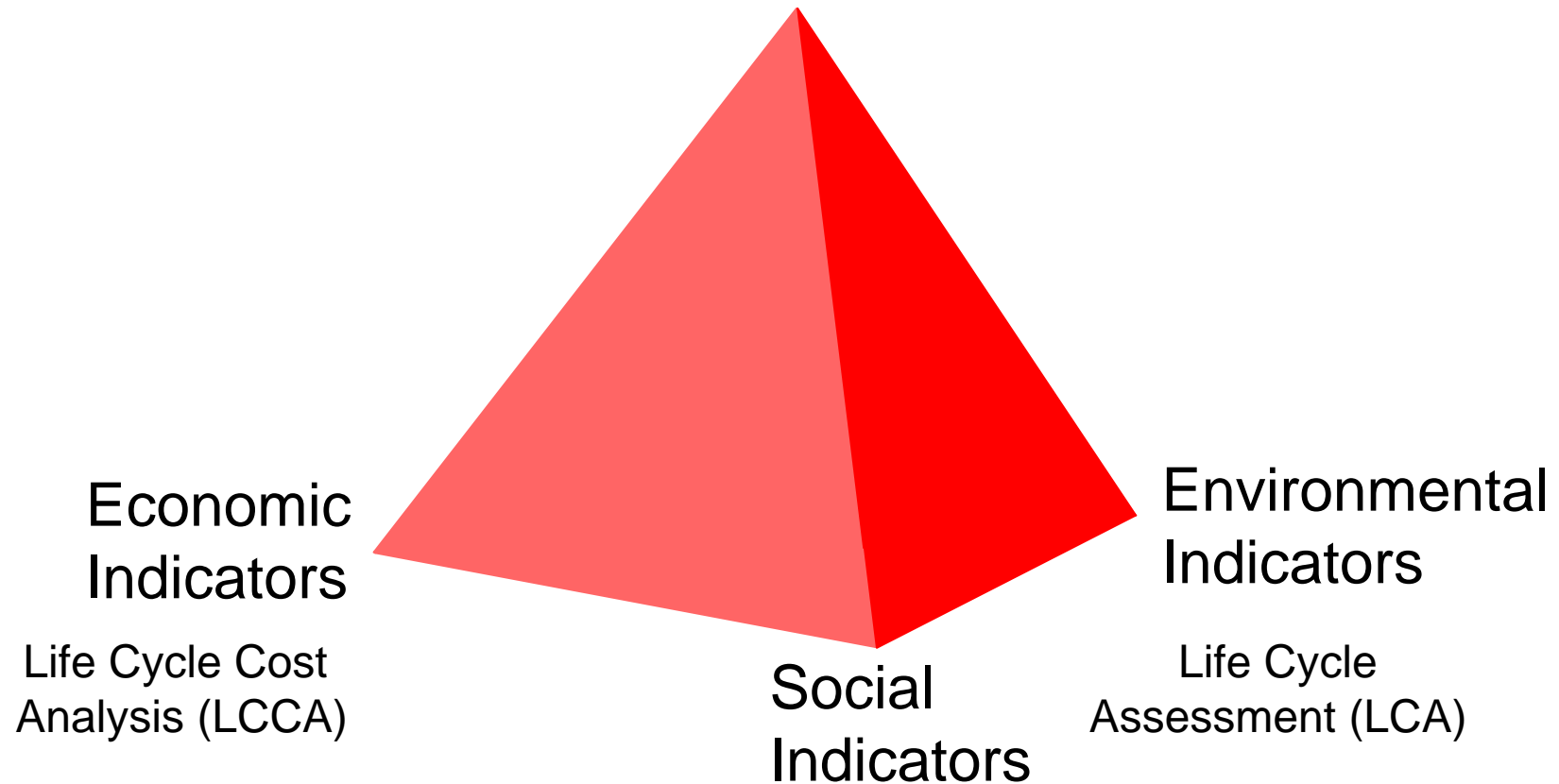
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- Input related categories
  - abiotic resource extraction
  - biotic resource extraction
  - land use
- Output related categories
  - global change (climate, ecosystem, etc.)
  - stratospheric ozone depletion
  - human toxicity
  - ecotoxicity
  - photo-oxidant formation
  - acidification
  - nutrification

# Life Cycle Assessment

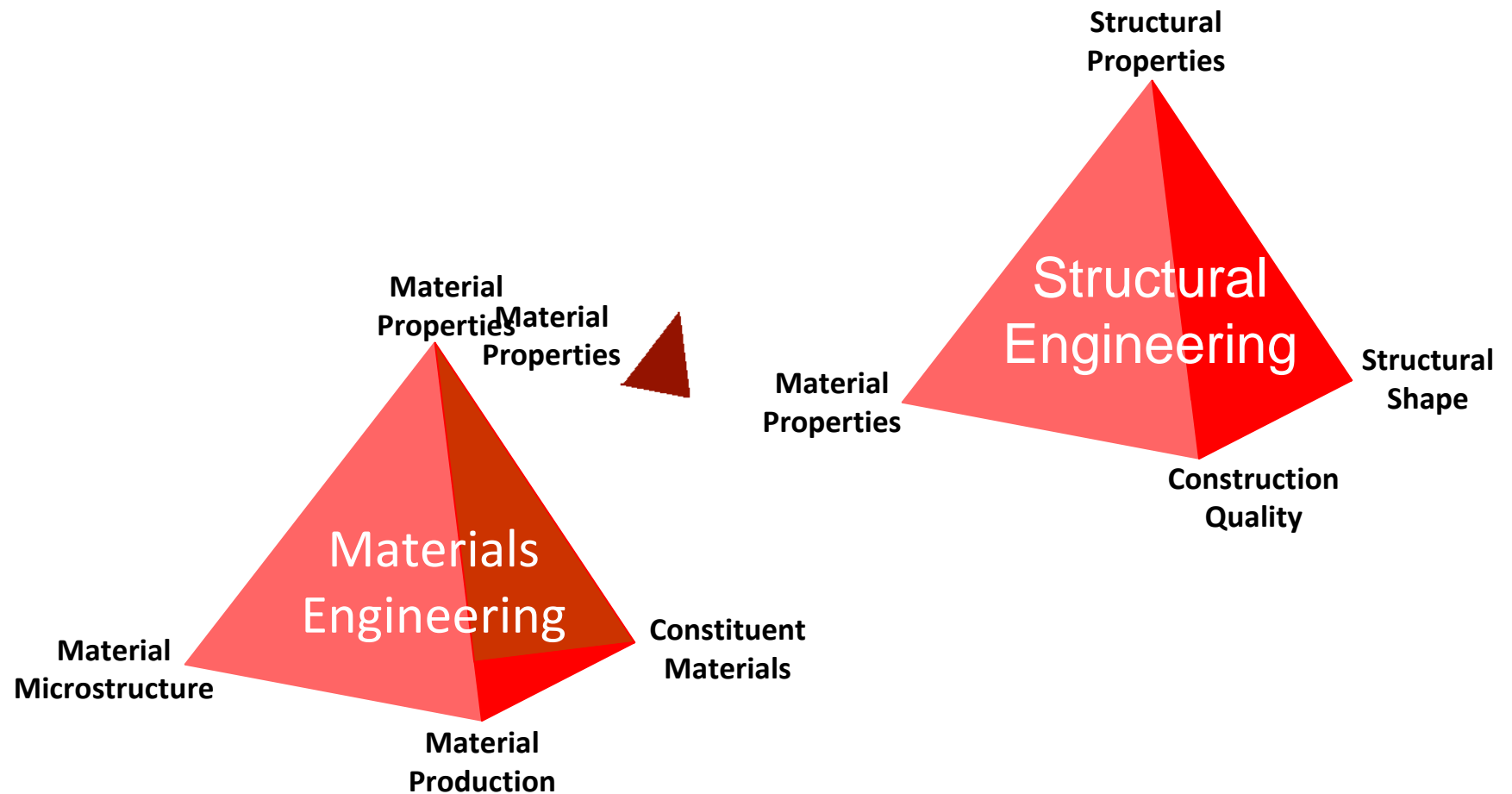
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## Sustainability Indicators



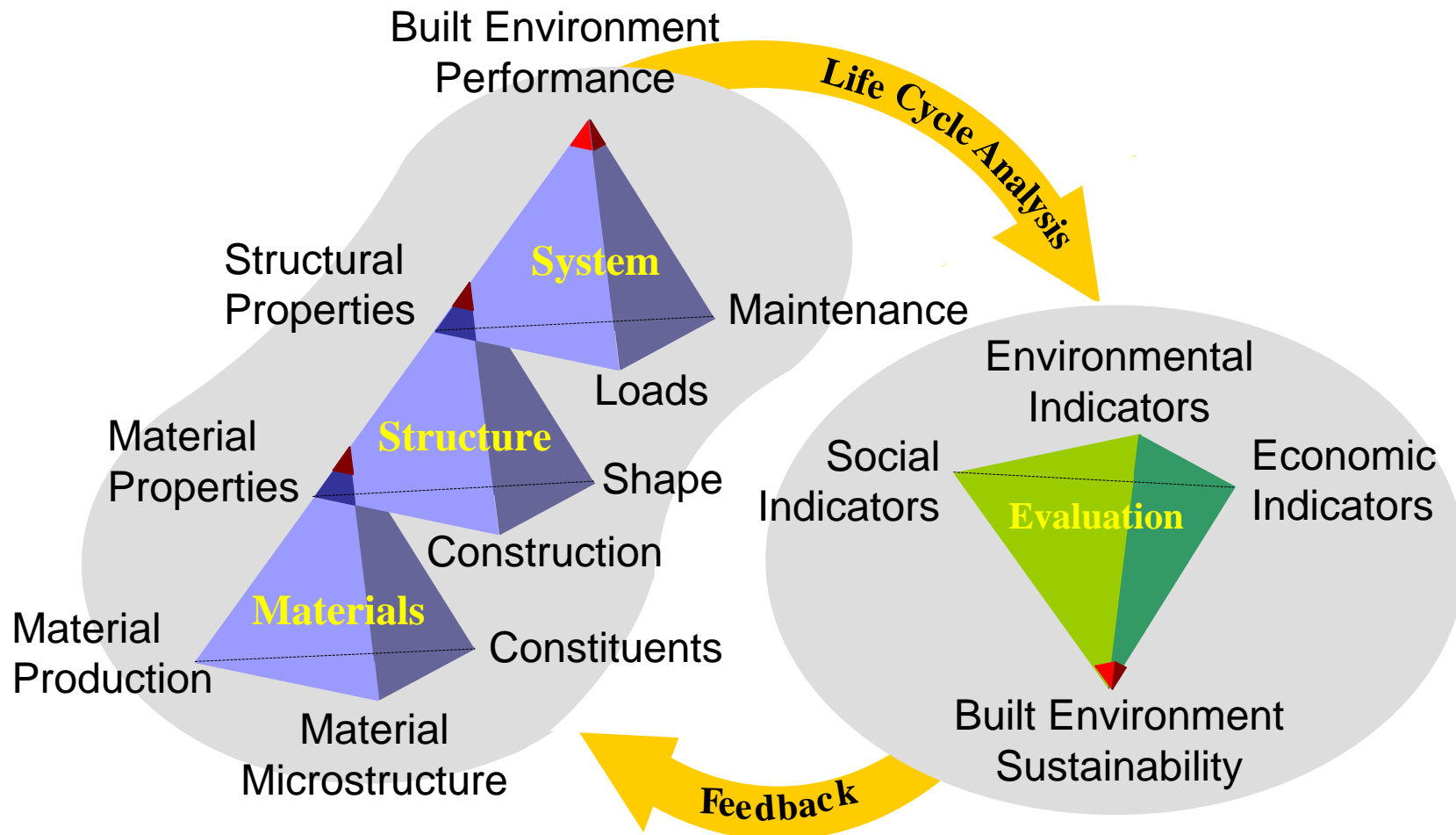
# How Do We Use LCA?

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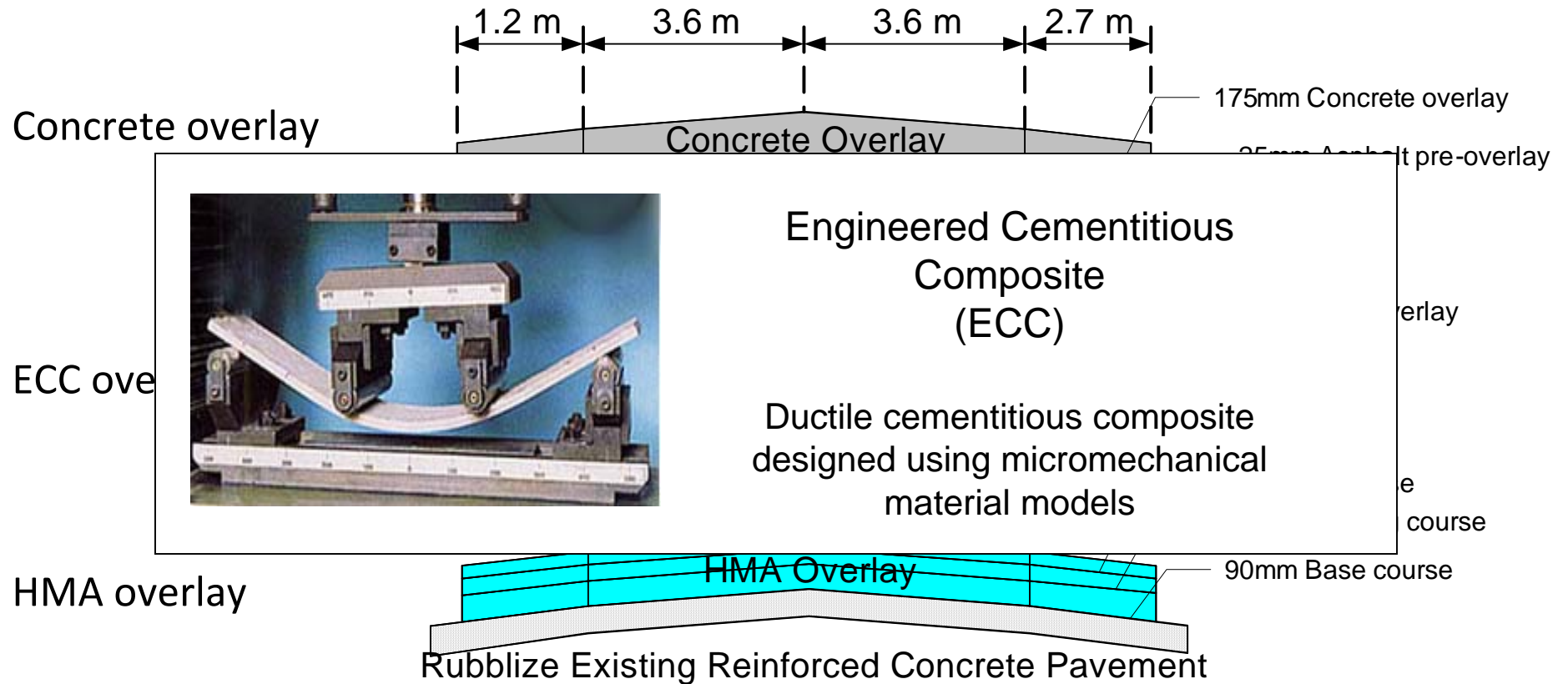


# SIMSS Design Approach



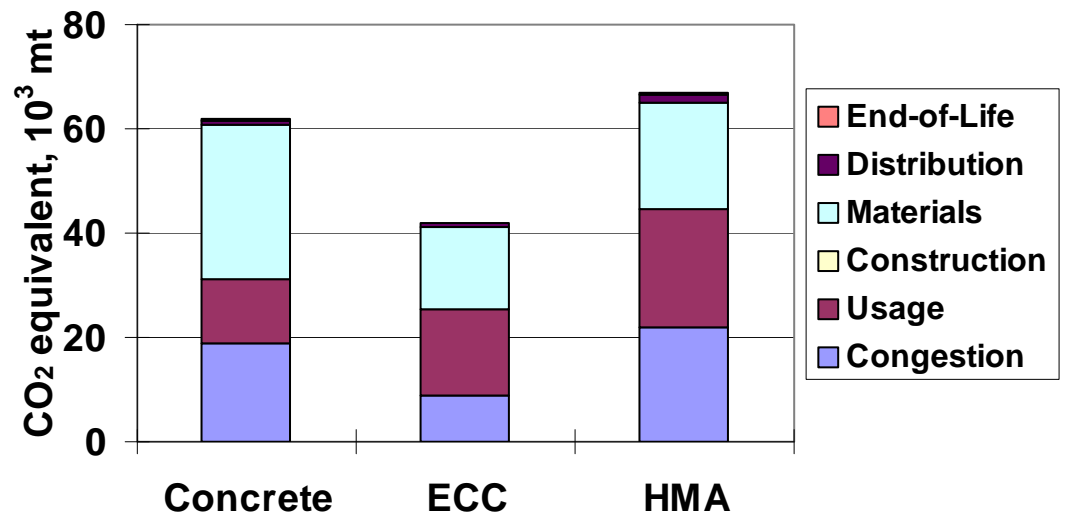
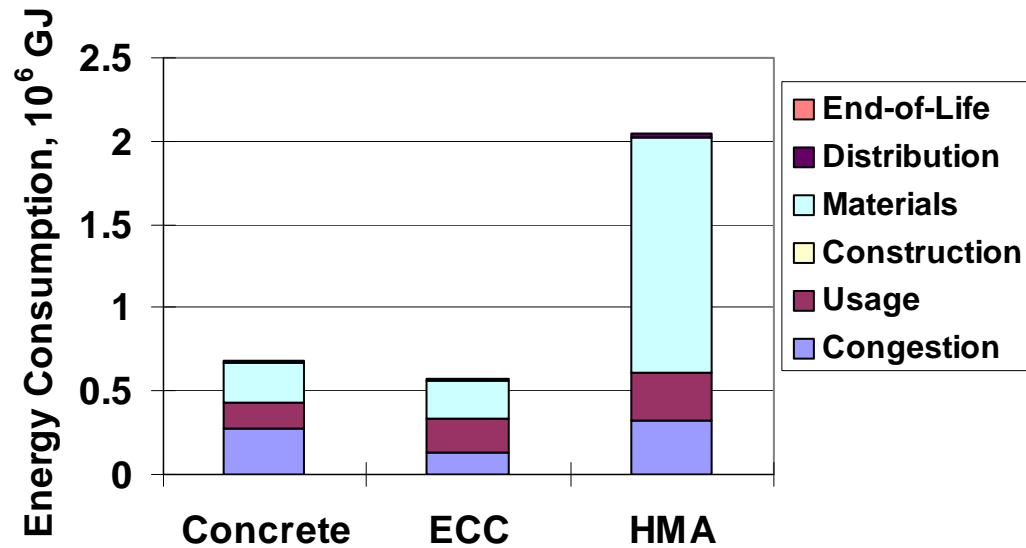
# Using LCA for Project Design

## Infrastructure Application – Pavement Overlays



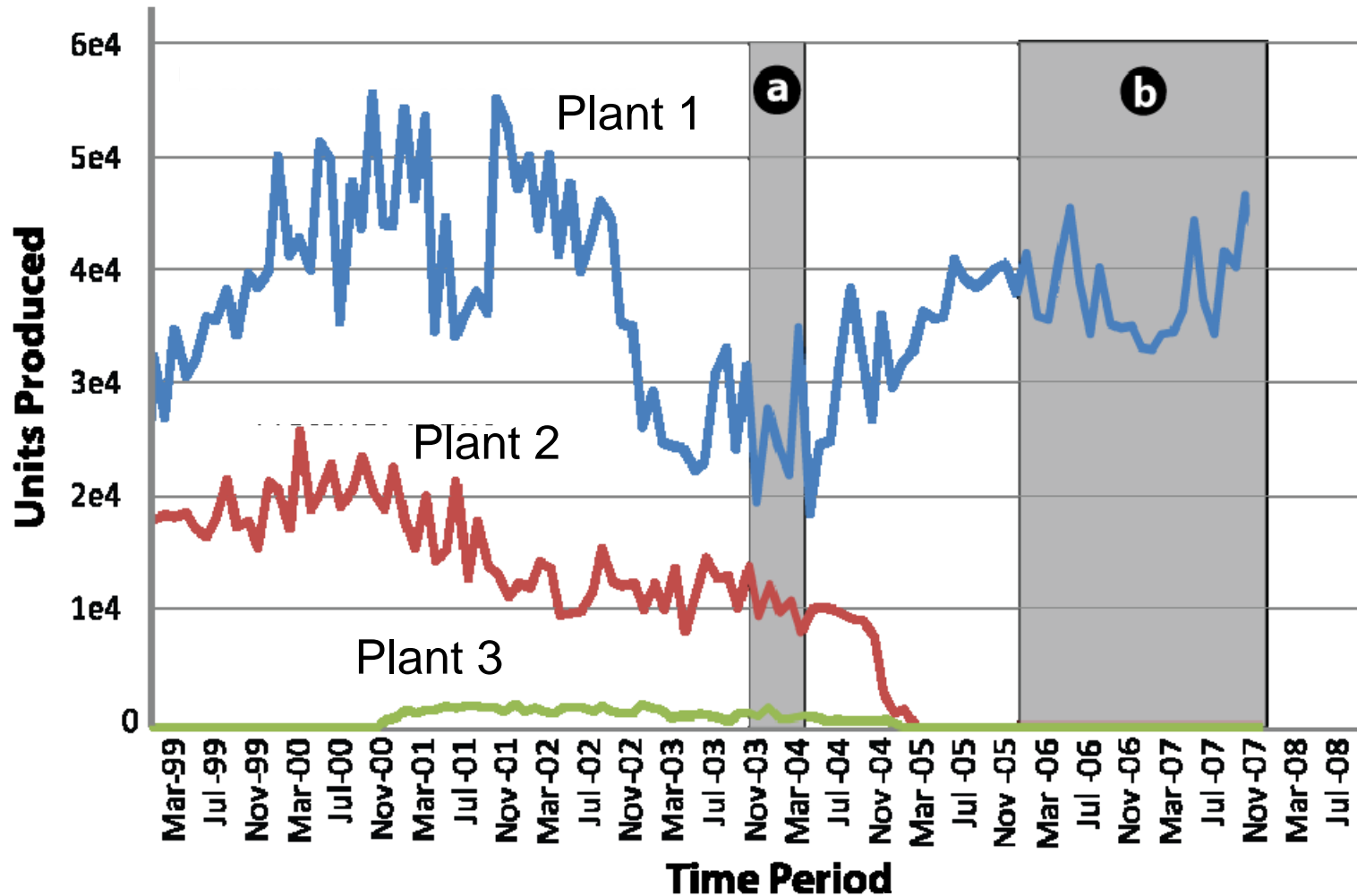
Overlay length is 10 km. Traffic flow is 70000/day (four lanes). Annual traffic growth rate is 0% in the baseline model.

# LCA Results

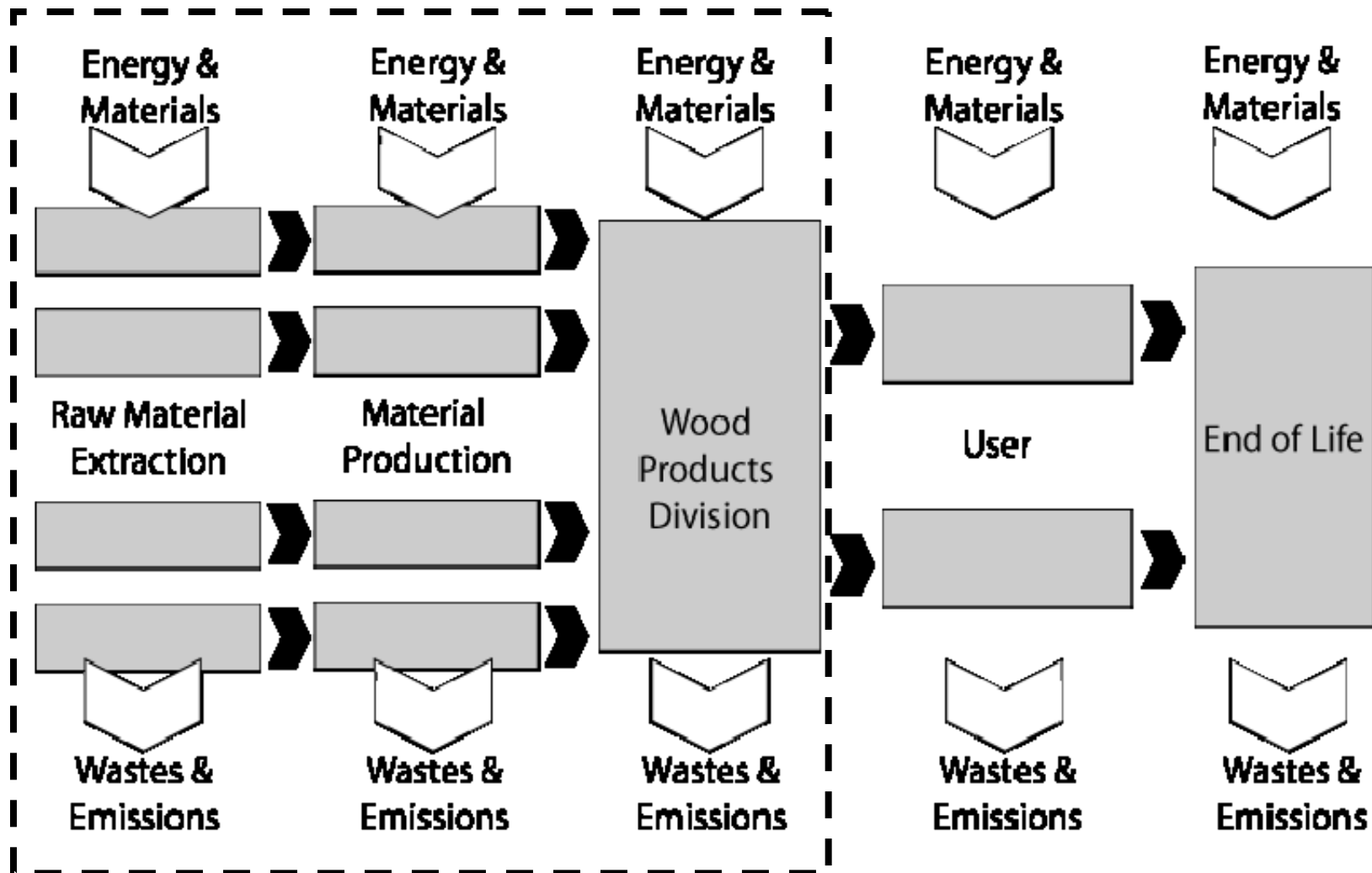


# LCA for Process Design

Process Application – Supply Chain Management and Corporate “Footprinting”

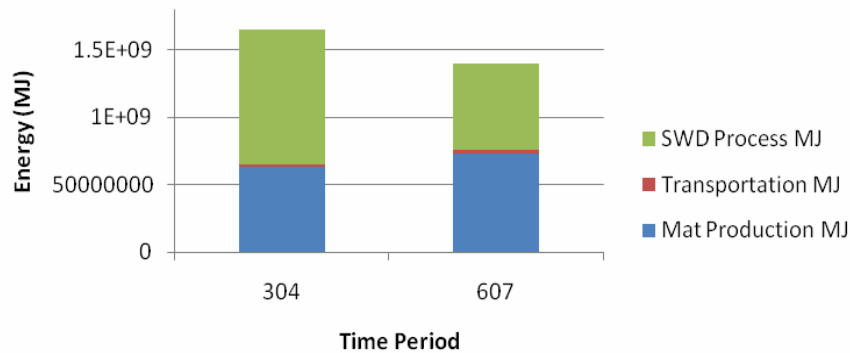


# Process Flow & Boundaries

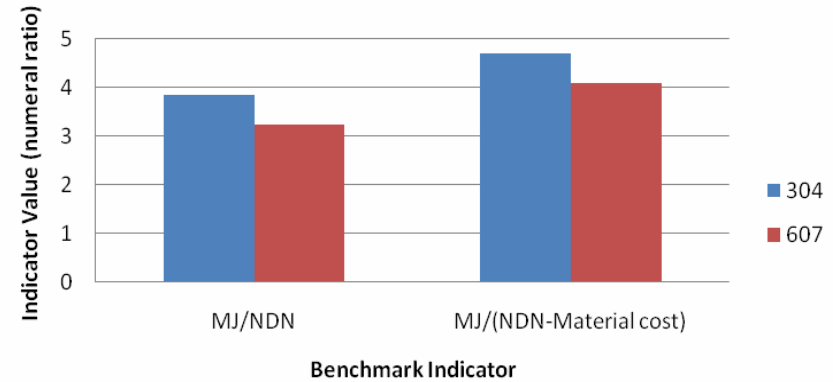


# Firm Performance

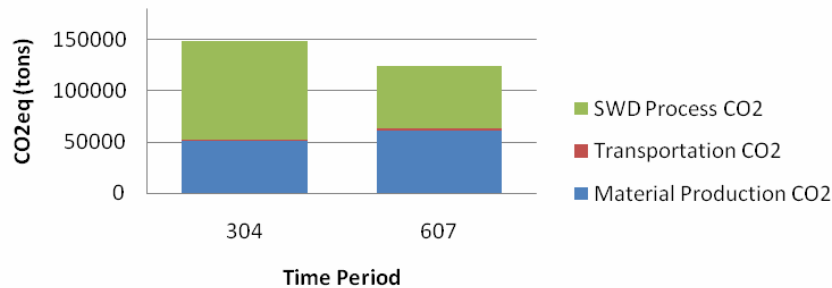
**Primary Energy  
Nov 03-Apr04 and 2006-2007**



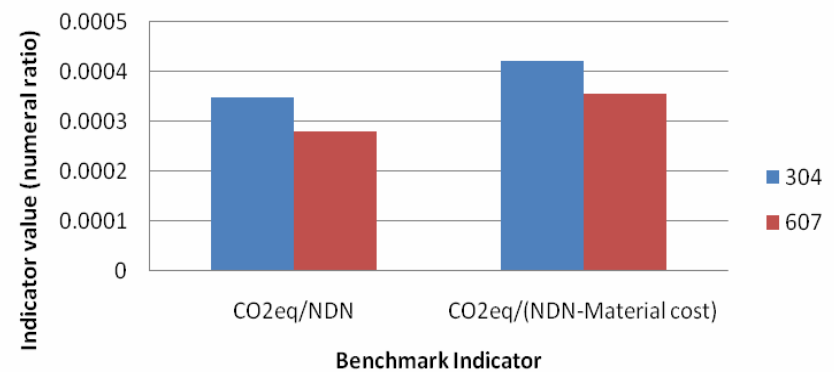
**Indicator Comparison Nov03-Apr04  
and 2006-2007**



**Total CO<sub>2</sub>eq.  
Nov 03-Apr04 and 2006-2007**



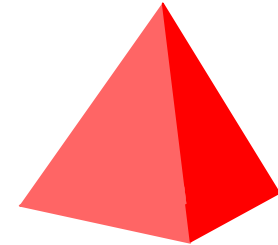
**Indicator Comparison Nov03-Apr04  
and 2006-2007**



# Overall Research Approach

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- The use of life cycle sustainability metrics in the design of complex systems
  - Built & Manufactured Systems (buildings, infrastructure, consumer products)
  - Processes (supply chains, transportation networks, business organizations)
- Application of the SIMSS design framework and analogous process-focused analysis frameworks



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# Questions

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