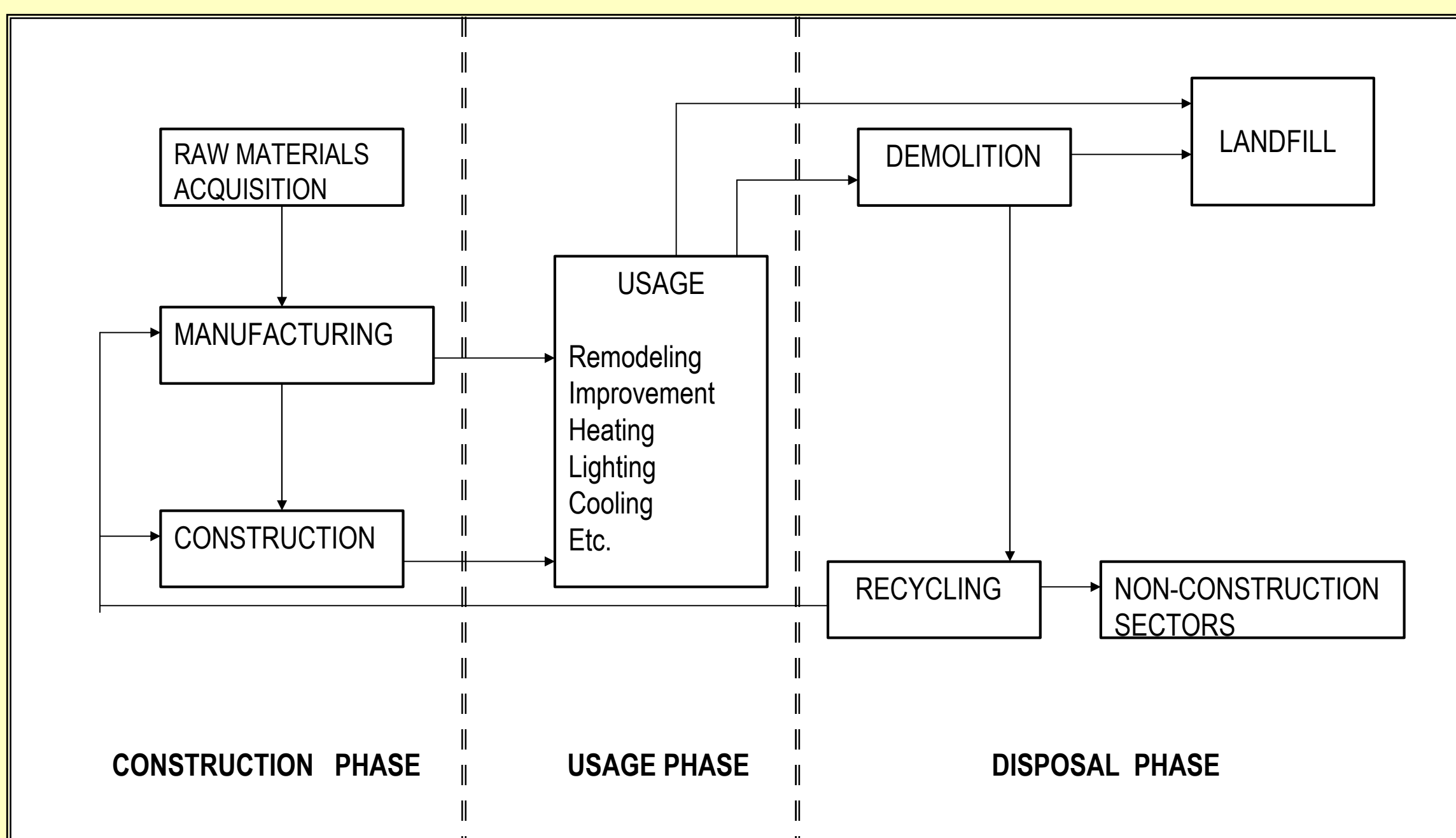


# Life Cycle Environmental Assessment of Residential Buildings

Luis Ochoa, Chris Hendrickson, Scott Matthews, Fran McMichael, and Robert Ries

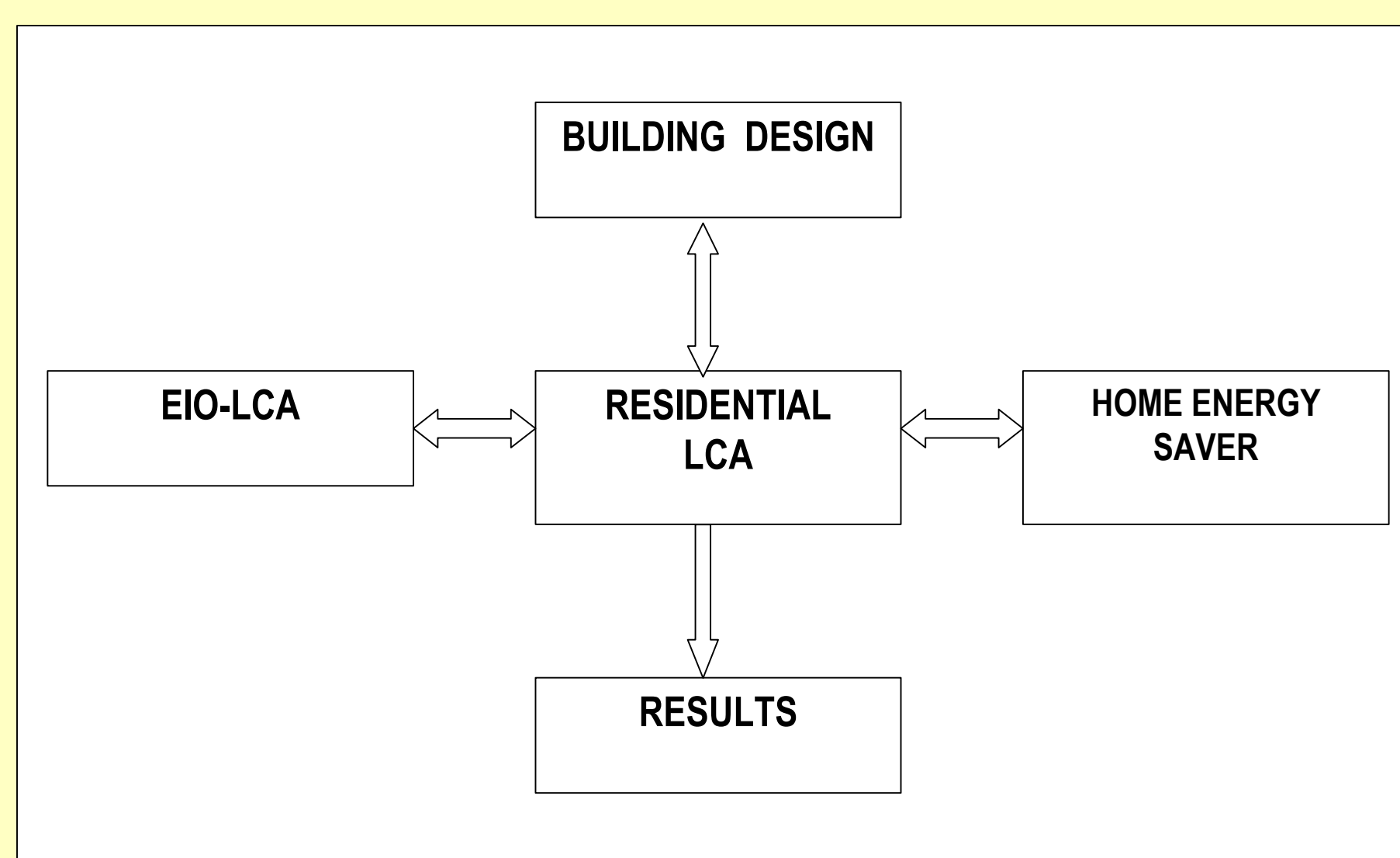


LCA Phases for Residential Buildings

## 10 Main EIO-LCA Sectors Used by the New Residential 1 Unit Structures, Nonfarm Sector

Eion	Sector Name	1992 \$ Million	Percentage	Cumulative Percentage
880000	Compensation of employees	39,248	33.99	34.00%
900000	Other value added	8,657	7.49	41.49%
690200	Retail trade, except eating and drinking	6,961	6.02	47.52%
690100	Wholesale trade	6,198	5.36	52.88%
200501	Millwork	2,445	2.11	55.01%
650301	Trucking and courier services, except air	2,227	1.92	56.94%
361200	Ready-mixed concrete	2,062	1.78	58.72%
320400	Miscellaneous plastics products, n.e.c.	2,059	1.78	60.51%
200200	Sawmills and planing mills, general	1,664	1.44	61.95%
520300	Refrigeration and heating equipment	1,561	1.35	63.30%

## LCA Model Architecture



## Inventory Analysis Scope

RESOURCES CONSUMED	ENVIRONMENTAL EMISSIONS
Electricity Used	Hazardous Waste Generated RCRA
Energy Used	Conventional Pollutants in Air
Ores	SO <sub>2</sub> (Sulfur Dioxide)
Iron	CO (Carbon Monoxide)
Copper	NO <sub>x</sub> (Nitrogen Dioxide)
Bauxite	VOC (Volatile Organic Compounds)
Uranium & Vanadium	PM10 (Particulate Matter Less than 10 microns in diameter)
Fuels	GWP (Global Warming Potential)
Bituminous Coal	CO <sub>2</sub> Carbon Dioxide
Natural Gas	CH <sub>4</sub> Methane
LNG	N <sub>2</sub> O Nitrous Oxide
LPG	CFCs Chlorofluorocarbons
Light Fuel Oil	Weighted TRI (Weighted Toxic Release Inventory. Method developed at CMU)
Heavy Fuel Oil	Air Releases
Fertilizers	Water Releases
	Land Releases
	Underground Releases

## Impact Assessment

VALUE FUNCTION	WEIGHT	UNITS	BENCHMARK	LCA RESULTS	COMPUTED GRADE	WEIGHTED GRADE
Electricity Used	10%	kw-hr	765,080.00	590,000.00	7.8	0.78
Energy Used	20%	Giga Joules	20,056.00	18,000.00	6.0	1.21
Ores	10%	mt	26.85	20.50	7.4	0.74
Fuels	10%	mt	509.62	450.00	6.2	0.62
Fertilizers	10%	Dollar	121.82	99.00	6.9	0.69
Hazardous Waste Generated RCRA	10%	mt	5.61	4.80	6.4	0.64
Conventional Pollutants in Air	10%	mt	2.68	2.00	7.5	0.75
Global Warming Potential	10%	CO <sub>2</sub> equiv	502.11	420.00	6.6	0.66
Weighted Toxic Release Inventory	10%	mt	0.85	0.63	7.6	0.76
SUM	100%		GLOBAL ENVIRONMENTAL INDICATOR =			6.85

## Objective

- Develop a model for life cycle environmental assessment of typical residential buildings (built since the 50s) in selected U.S. regions (Pittsburgh, Los Angeles, Miami, San Antonio, and New York)
- Consider entire life cycle: Construction; Usage; Disposal
- Consider direct and indirect effects of all economic sectors involved
- Frame study within the ANSI/ISO 14040 "Environmental Management Life Cycle Assessment, Principles and Framework"
- Insure an interactive, customizable model

## Sources & Tools

- For Building Design: RSMMeans Residential Cost Data
- For Inventory Analysis: Economic Input-Output Life Cycle Assessment (EIO-LCA)
- For Energy Consumption: Home Energy Saver (Department of Energy)
- For Maintenance Patterns: National Association of Home Builders (NAHB)

## Inventory Analysis

- Quantification of resources consumed and environmental emissions based on the EIO-LCA model
- Sensitive to the geographical house location

## Impact Assessment and Interpretation

- Quantitative estimation for resources consumed and environmental emissions
- Sustainability index through multiattribute analysis
- Value functions weighted by user
- Benchmarks are defined by typical cases (grade = 5)
- An increment of 10% in the computed value for a value function = A one grade decrement from "5"
- Example:
  - Benchmark = 1000
  - Computed value = 1150
  - Computed grade = 5 + (1000 - 1150) \* 1 / (0.1 \* 1000) = 3.85
- Negative grades are possible
- Value function grades are multiplied by their given weight (0 to 100%)
- Weighted grades are added up to obtain a global environmental indicator
- A higher value = higher sustainability
- Expected variation = 0 to 15

## Implementation

- Spreadsheet: Data Repository and Interactive User Interface (Excel®)
- Possible upgrade to an on-line version

More information: Luis Ochoa: [lao@andrew.cmu.edu](mailto:lao@andrew.cmu.edu)

## Spreadsheet User Interface Front Page