Introduction to LCA: The Environmental Performance Yardstick

Municipal Scoping Workshop

InLCA/LCM 2003

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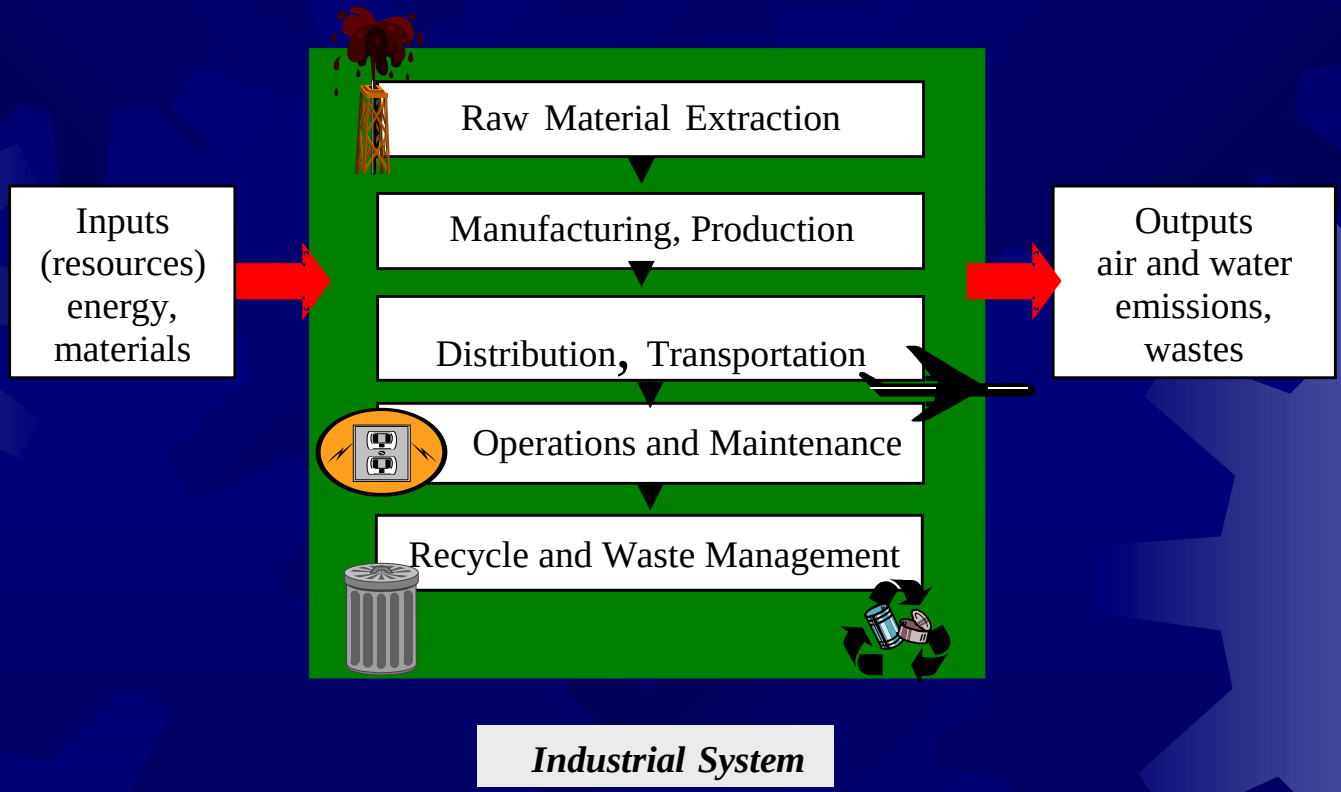
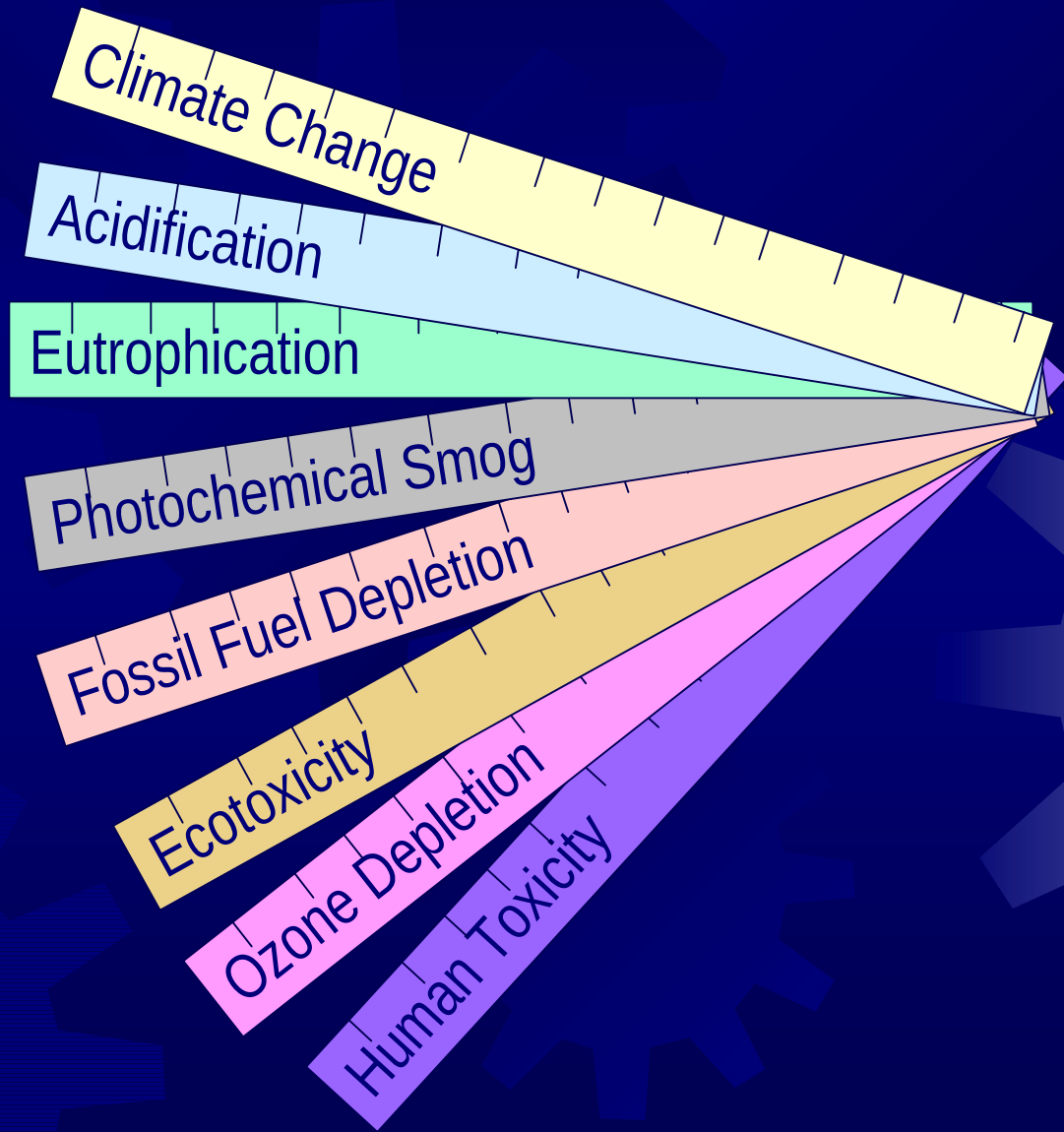
LCA is a Measurement System

- Based on:
  - Systems analysis (holistic)
  - Mass balance input-output inventory
  - Indicators system for impact assessment
- Useful for decision-making
  - Environmental Management
  - Design for Environment
  - Communication
- Usually follows international rules (the ISO 14040 series standards)

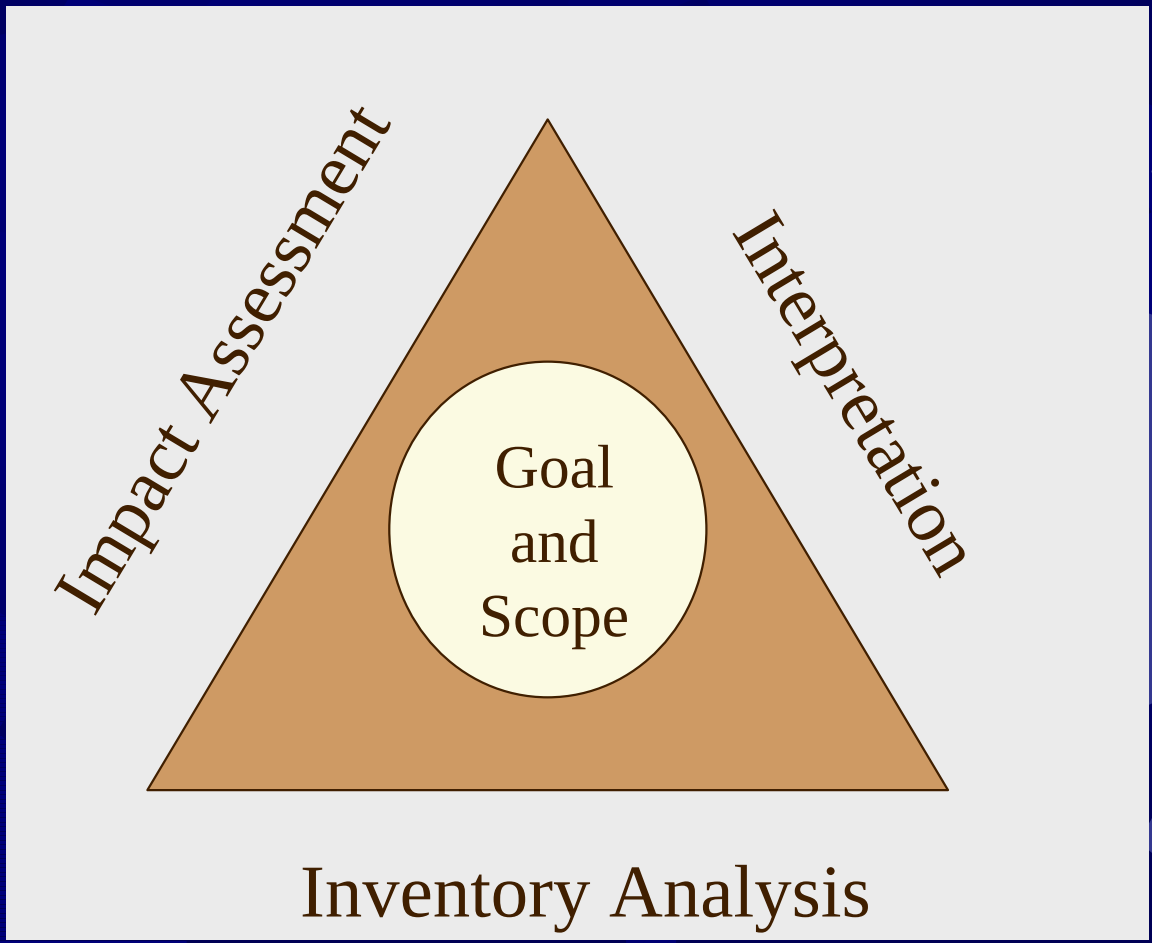
Entire Systems, Cradle to Grave



Indicators for All Impact Categories



Phases of a Life Cycle Assessment

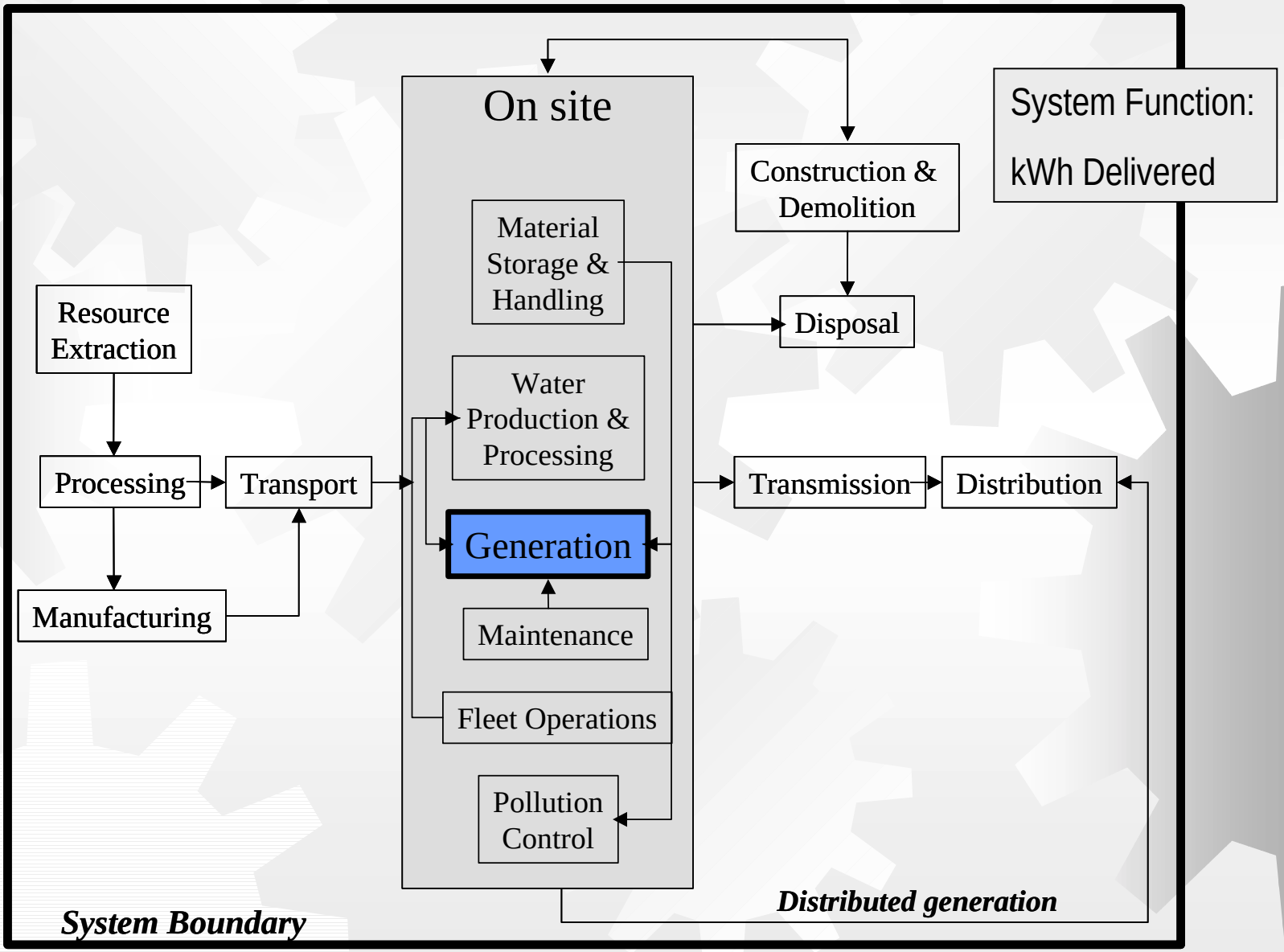


Scoping

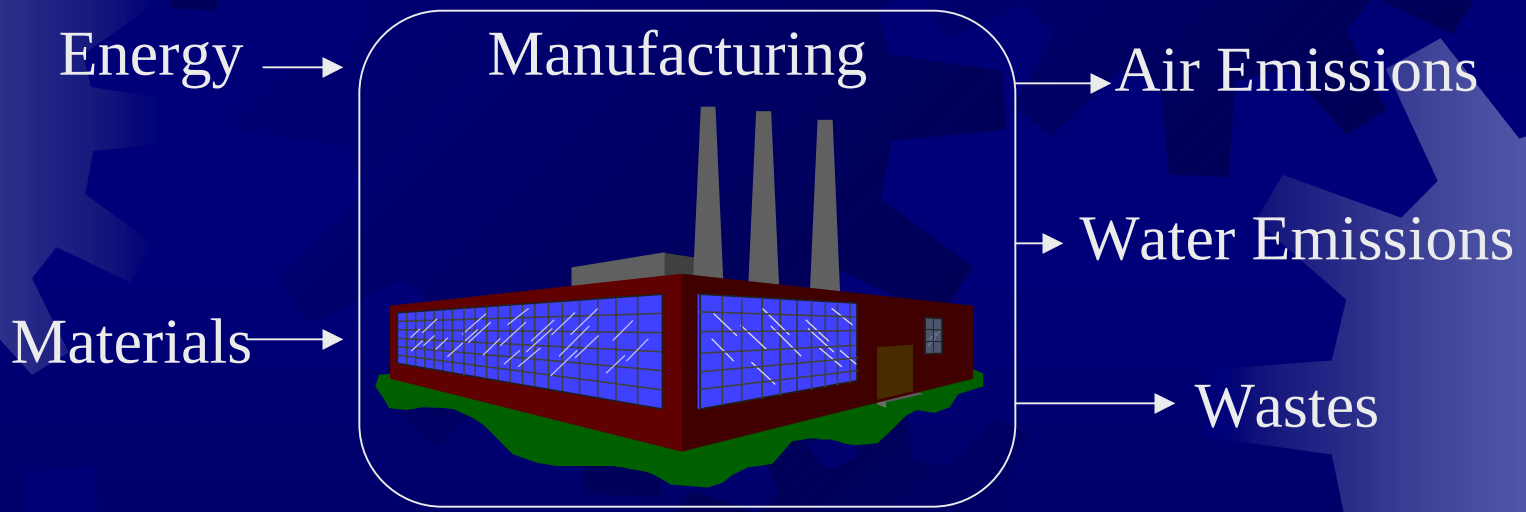
- The system function and functional unit: the economic or social good provided by the goods or services in question.
- Impact categories: which environmental concerns are included and which are excluded
- The system boundary: which processes are included and which ones are excluded

- The audience of the LCA and therefore whether it will be a public and peer reviewed document.
- Technical issues such as engineering conventions and impact assessment models

Power Generation System



Mass and Energy Inventory



FLOWS for Power Generation

Not a comprehensive list, but a minimum list

Resources

- Electricity (location)
- Water (location & type)
- Fuel (in ground)
- Minerals (in ground)
- Biomass (harvested)
- Land use (area & location)

Wastes

- Solid waste
- Radioactive Waste (high, low, medium)
- Hazardous Waste

Air

- CO_2
- CO
- PM (10, 2.5)
- CH_4
- SO_X
- NO_X
- NH_3
- Hg
- Pb
- VOC (NM)
- Dioxin
- PAH's

Water

- COD
- TDS
- TSS
- BOD (5,7,10)
- Flow
- ΔTemperature
- NH3 (as N)
- TKN (as N)
- NO3, NO2 (as N)
- PAH's
- Phosphates (as P)
- Cu
- Ni
- As
- Cd
- Cr
- Pb
- Hg

Steel Energy System Inventory (Partial) Courtesy Steel Recycling Institute

Process	Production		Coke Ton		Electricity kWh		Steam 1000 MJ		BF gas 1000 MJ		COG Gas 1000 MJ		Natural gas 1000 MJ	
	units / year	unit	input	Output	Input	output	input	output	input	output	Input	output	input	output
Coking														
Coking	4,160,494	ton		4,160,494	576,490,299		5,527,968				10,595,272			
COG Gas prod. 1)	41,862,808	1000 MJ			199,554,334		1,913,527				3,667,594	41,862,808		
By–products	15,901,671	1000 MJ			75,801,111		726,857				1,393,143			
Power plant						206,508,059		8,168,353			11,535,529			
Coking Total				**4,160,494**	**851,845,744**	**206,508,059**	**8,168,353**	**8,168,353**			**27,191,539**	**41,862,808**		
Steel Production														
Blast Furnace	2,026,754	ton	911,315		76,800,000	285,078,053		1,927,150		9,501,638	5,304,800		4,307,381	
BOF Steel making	2,543,123	ton			283,600,000						141,765		151,891	
Cont.casting/ cutting	2,543,123	ton			69,600,000									
Other							11,929,079							
Power plant 1					3,708,000	155,504,541		3,378,327	3,206,225		629,759		125,711	
Power plant 2					3,662,234	152,972,644		3,323,523	3,199,662		871,421		173,913	
Power plant 3					3,654,096	151,867,816		3,300,079	3,095,462		1,046,925		210,874	
Steel Production Total			**911,315**		**441,024,330**	**745,423,054**	**11,929,079**	**11,929,079**	**9,501,349**	**9,501,638**	**7,994,670**		**4,969,770**	
Steel Forming														
Hot strip mill	2,396,124	ton			262,700,000						4,712,424		1,077,162	
Pickling	1,305,075	ton			13,100,000		190,056							
Cold rolling	1,121,247	ton			109,500,000									
Ann. & tempering	762,485	ton			43,800,000						555,669		111,176	
Hot–dip galvanizing	239,990	ton			8,760,000								240,494	
Other							355,734							
Power plant 4								190,013			213,107		24,463	
Power plant 5								252,636			284,023		31,772	
Power plant 6								54,316			60,415		7,480	
Power plant 7								48,825			55,422		5,609	
Steel Forming Total					**437,860,000**		**545,790**	**545,790**			**5,881,060**		**1,498,155**	
Total Steel System			**911,315**	**4,160,494**	**1,730,730,074**	**951,931,113**	**20,643,222**	**20,643,222**	**9,501,349**	**9,501,638**	**41,067,268**	**41,862,808**	**6,467,925**	
External import (+)/export (-)				3,249,179		778,798,961		0		-289		-795,539		6,467,925

Life Cycle Impact Assessment

- Uses the inventory data
- Models Indicators, not actual impacts
- Indicators are assumed to correlate with impacts
- Takes hundreds to thousands of data points and boils them down to 10-12
- Outcome is the ecoprofile

Typical List of Environmental Impacts Categories

- Climate Change
- Stratospheric Ozone Depletion
- Eutrophication
- Photochemical Smog
- Acidification
- Human Toxicity
- Eco-Toxicity
- Water Resource Depletion
- Mineral Resource Depletion
- Fossil Fuel Depletion
- Land Use/Biodiversity
- Soil Conservation

Example Impact Assessment

- Climate Change
- Uses air emissions inventory of CO_2, N_2O, CH_4 and others
- Measure Global Warming Potential
- Does not measure effects of droughts, floods, sea level rise or local warming

After Impact Assessment

- Normalization, Scoring and other methods
- Used to clarify data for decision makers
- Based on value judgments, not science
- Important to choose these methods to support the decisions you make
  - E.g. policy: normalized to national per capita figures
  - E.g. comparisons between products, normalized to average product
  - E.g. comparisons between businesses normalized to net sales

Ecoprofile & Normalized Ecoprofile

	Units	Grams per pound of meat	Percent of U.S. Average
Climate Change	CO_2	200	75
Stratospheric Ozone Depletion	Freon 13	0.002	25
Eutrophication	P	50	70
Photochemical Smog	O_3	40	50
Acidification	SO_2	0.2	70
Airborne Toxicity	toxic volume	0.08	10
Waterborne Toxicity	toxic volume	0.01	5

Why Bother with LCA

- Gives you a measurement stick that helps you think holistically, helps avoid unintended consequences
- Pinpoints places where process improvements can yield environmental benefits (tool for DfE)
- Rationalizes environmental management, especially when applied across businesses and jurisdictions: focus is on performance, not compliance
- Tool for value chain management: vendors and customers
- Good communication tool for customers and employees: market advantage

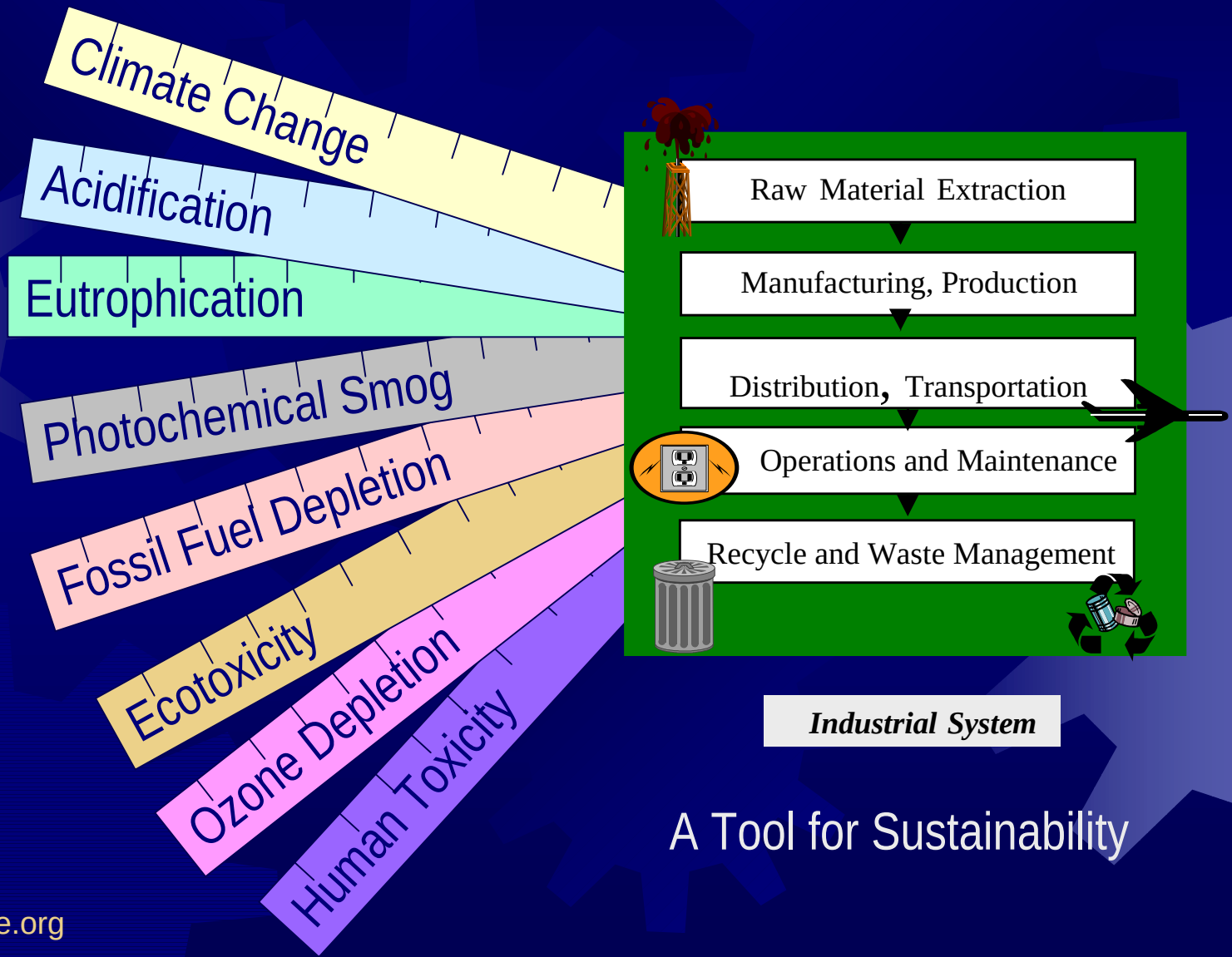
Environmental Product Declarations (EPD)
Radio Base Station Ericsson

	Unit	Manufact.	Transport	Use	Total
Greenhouse Gases	kg CO2-	11,400	1360	142000	155,000
Ozone-Depleting Gases	mg CFC11	100	0	39	139
Ground Level Ozone	g ethene	9610	1170	225,000	236,000
Acidifying Gases	mol H+	2950	162	35,400	38,500
Eutrophication potential	kg O2 equ	535	32	2,300	2,870

Interpretation Phase

- Reviews data quality
  - Accuracy of numbers
  - Support of goal and scope
- Makes recommendations:
  - What do the numbers mean?
  - What actions should be taken?
- Not always done in LCA, or done cursorily (some important exceptions)

Life Cycle Assessment: The Holistic Yardstick of Environmental Performance



A Tool for Sustainability

www.iere.org

LCA Scoping: How to do it

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The System Function and Functional Unit

- Functionality is about what *benefits* a product or service provides
- Many *very different* systems can provide the same benefit
- We need to be very clear about the benefits we are seeking in order to make correct comparisons between products

System Function/Functional Unit

- Only unique part of LCA
- Connects social benefits (goods and services) to environmental impacts
- Makes the Market drive environmental improvement
- Often includes quality and duration
  - E.g. paints: square meters meeting government standards for 5 years
  - E.g. cars: 1 million passenger vehicle miles traveled

Example System Function and Functional Unit

- Products to extend the life of a road
- Function: keep road travelable, at least average condition: compare asphalt w/emulsion
- Functional unit: Area, time, quality=
  - 0ne lane-mile for 10 years at average condition (via DOT rating system)
- *Note: we didn't look for non-product solutions*

Improvisational Theater: System function

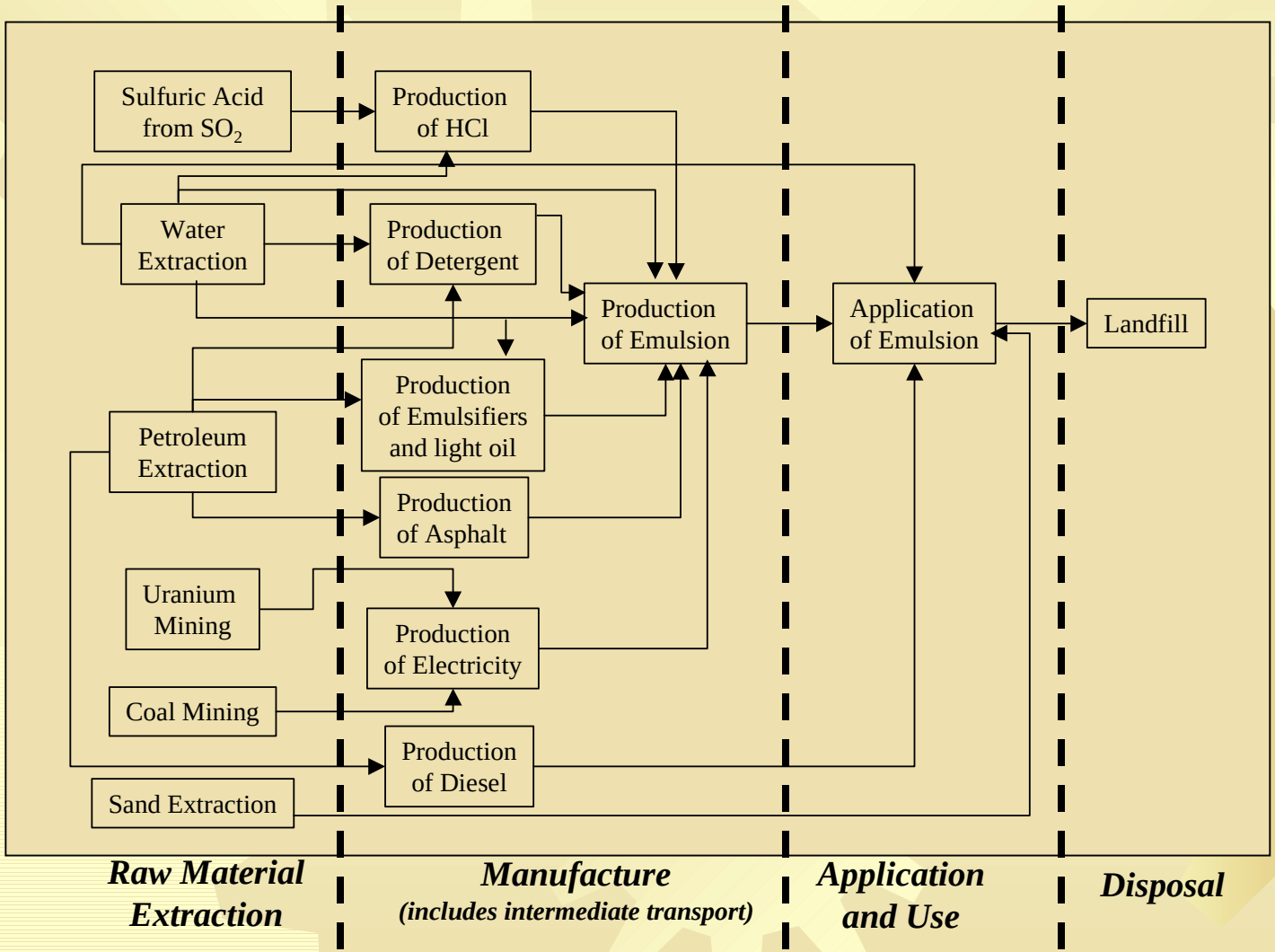
System Boundaries: what's in, what's out

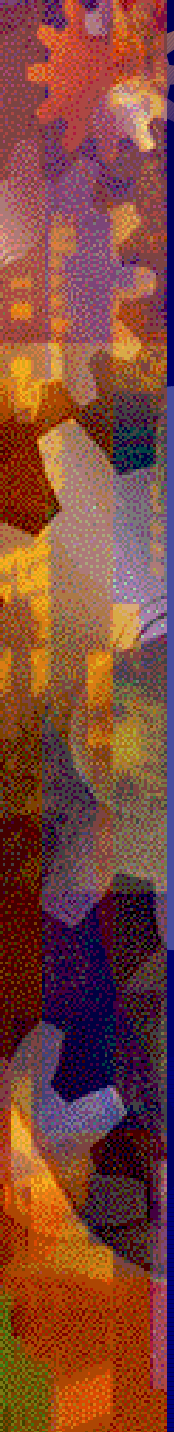
- Decide which life cycle stages
- Decide which unit processes
- Decide which environmental issues (a.k.a. impact categories)

Asphalt Emulsion

System Function:
20 year lane mile in average condition

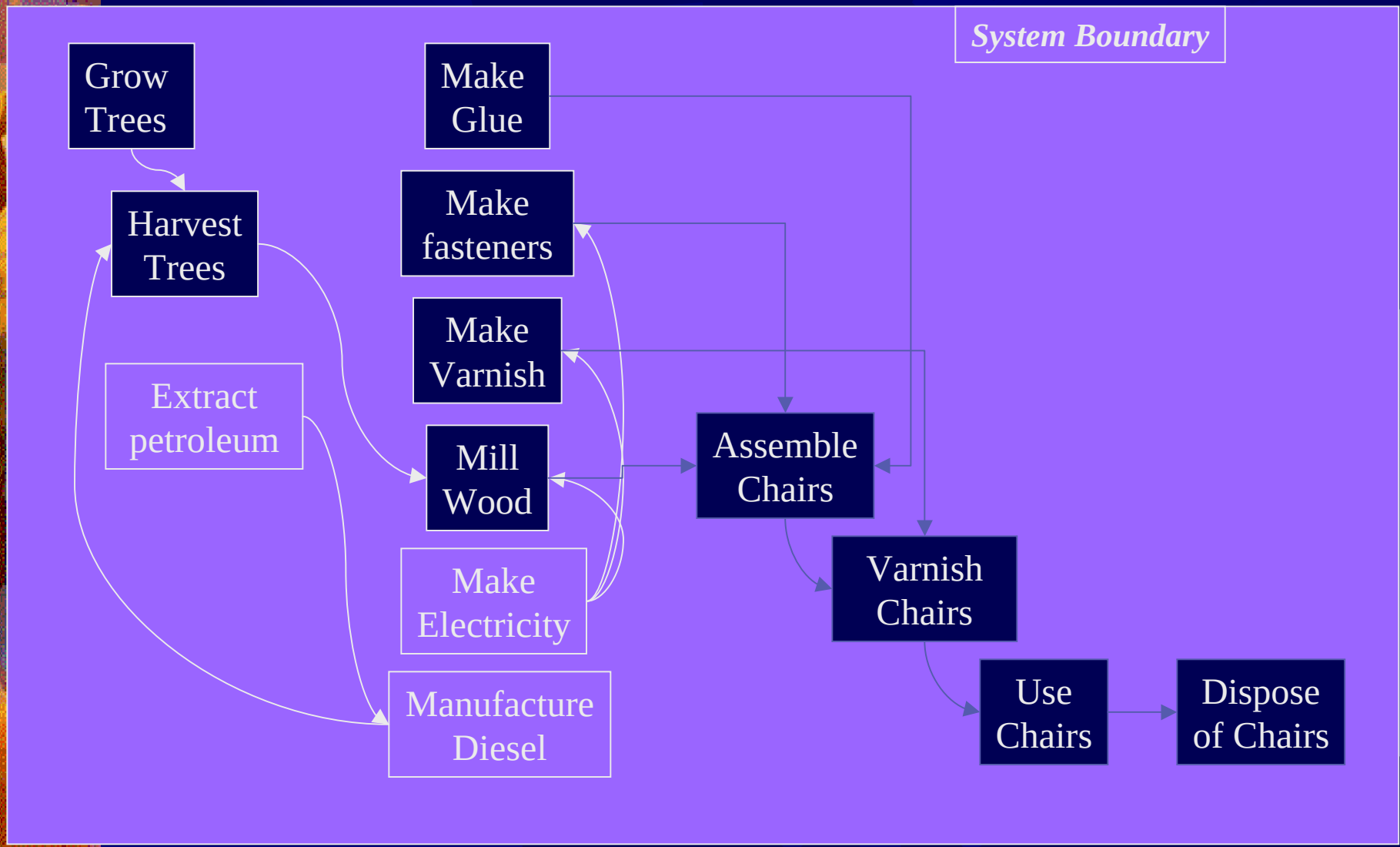
Asphalt Emulsion Coating (GSB 88)





More Improv: System boundaries

System for Wooden Chairs



Potential List of Impact Categories (the biggies)

- Climate Change
- Land Use/biodiversity
- Acidification
- Eutrophication
- Aquatic toxicity
- Fossil Fuel Depletion
- Airborne toxicity

The Secret to Scoping

- Scoping is FUN
- You already have the skills to do this!
- The more creative the scoping, the better the LCA
- LCA scoping is really another name for Life Cycle Thinking