What role can Life Cycle Assessment play in the selection of green construction materials?

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Outline

- **Environmental sustainability in perspective**
- **Life Cycle Assessment (LCA) in a nutshell**
- **Construction life cycle phases and environmental impacts**
- **LCA-based considerations for materials selection**

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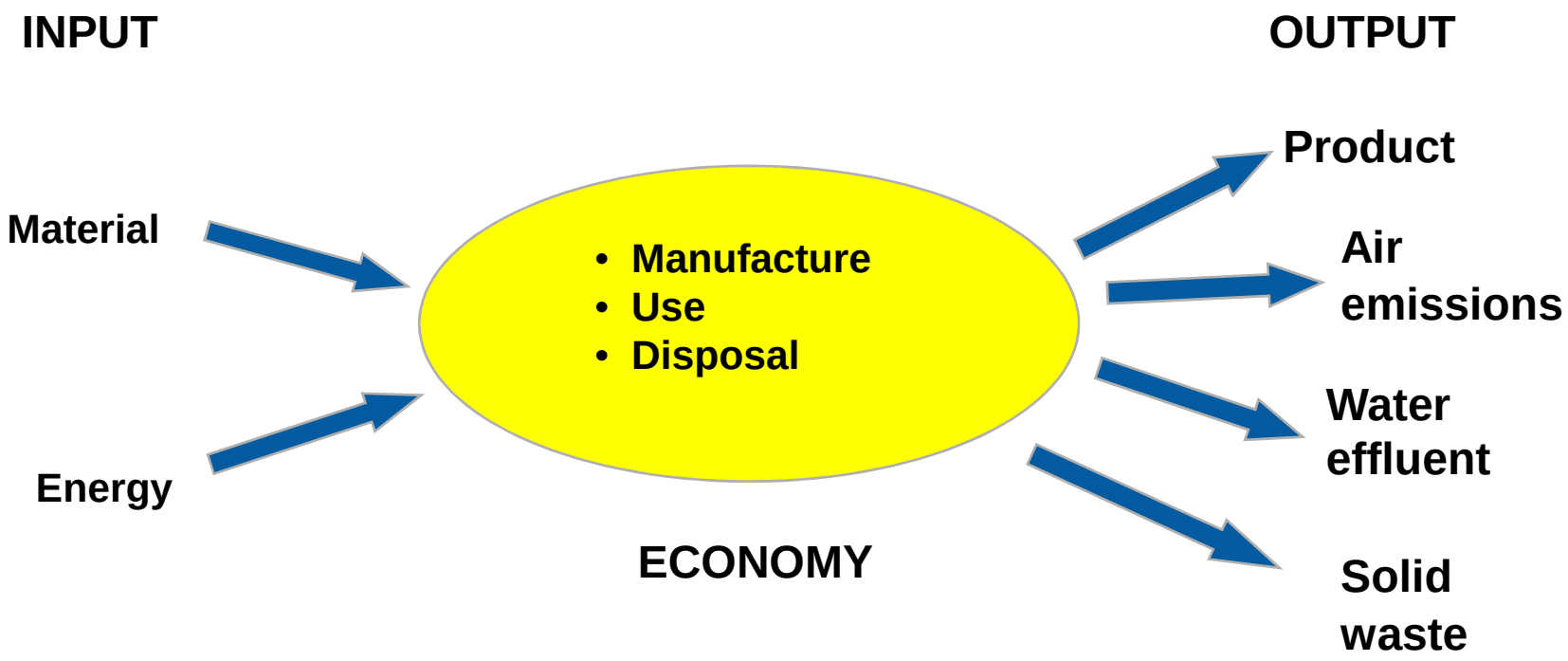
Environmental sustainability in perspective

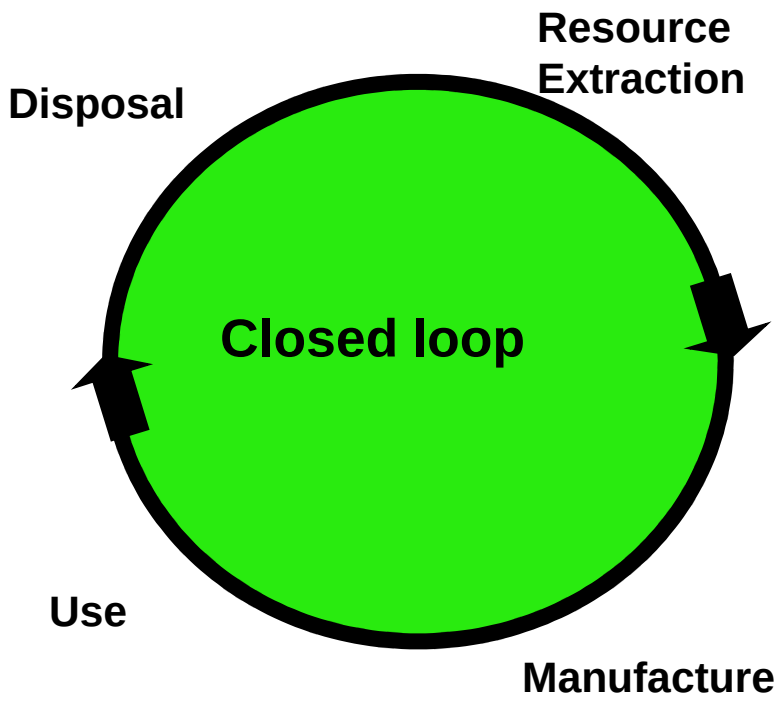
Environmental sustainability in perspective



Prerequisites for environmentally sustainable "green economy"

- ✓ Preserve input capability
- ✓ Absorb pollution (air, water, soil)

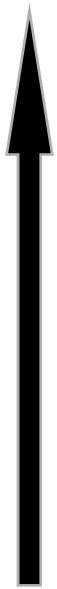
Environmental sustainability in perspective



Life cycle of "natural economy"

✓Efficiency

✓Zero pollution



Open loop

Disposal

Use

Manufacture

Resource Extraction

Life cycle of conventional "human economy"

✓Inefficiency

✓Excessive pollution

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Environmental sustainability in perspective

Attributes of the "construction economy"…….

Inputs (global)

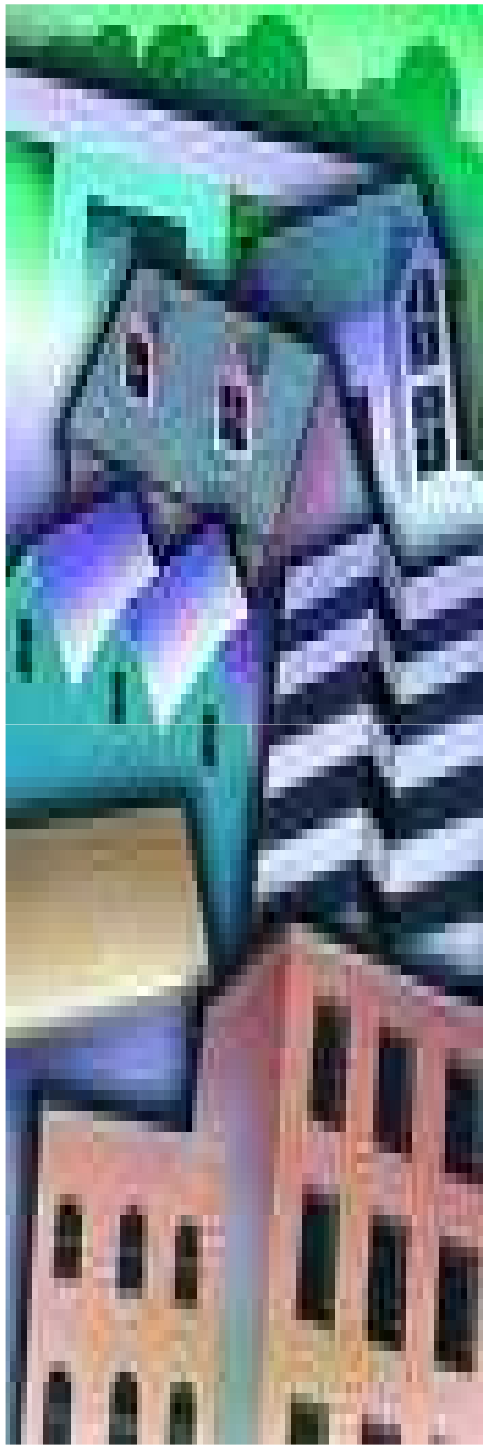
- ✓ **Raw materials: 50%**
- ✓ **Energy : 50%**

Outputs (global)

- ✓ **Solid waste: 50%**
- ✓ **Air pollution: 40%**

……. are not aligned with the purpose of Sustainable Construction, i.e.

"***Creation and operation of a healthy built environment based on ecological principles and resource efficiency".***



Environmental sustainability in perspective

The challenge: mismatch between intents and practice……

- Renewability = no environmental impact ?
- Low embodied energy = low GHG emissions ?
- Recycled content = material efficiency ?

Wrong answers may carry as much weight as the right ones

…… Life Cycle Assessment (LCA) can help

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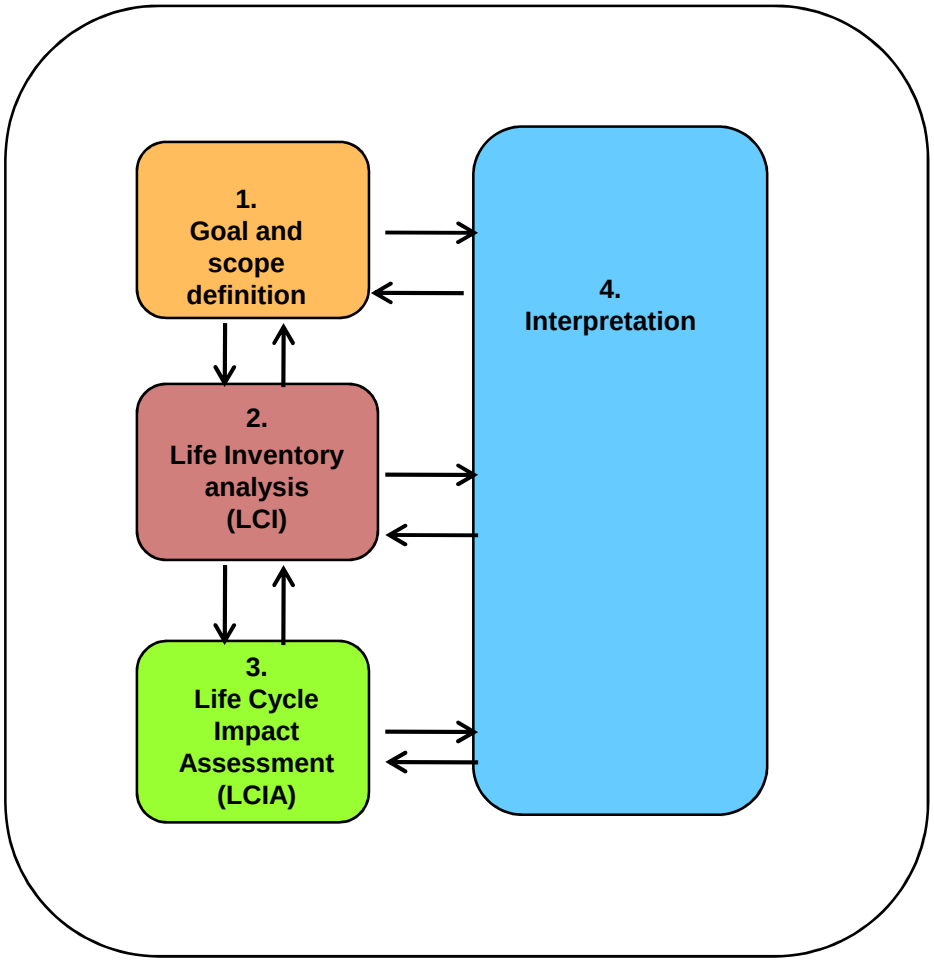
LCA in a nutshell

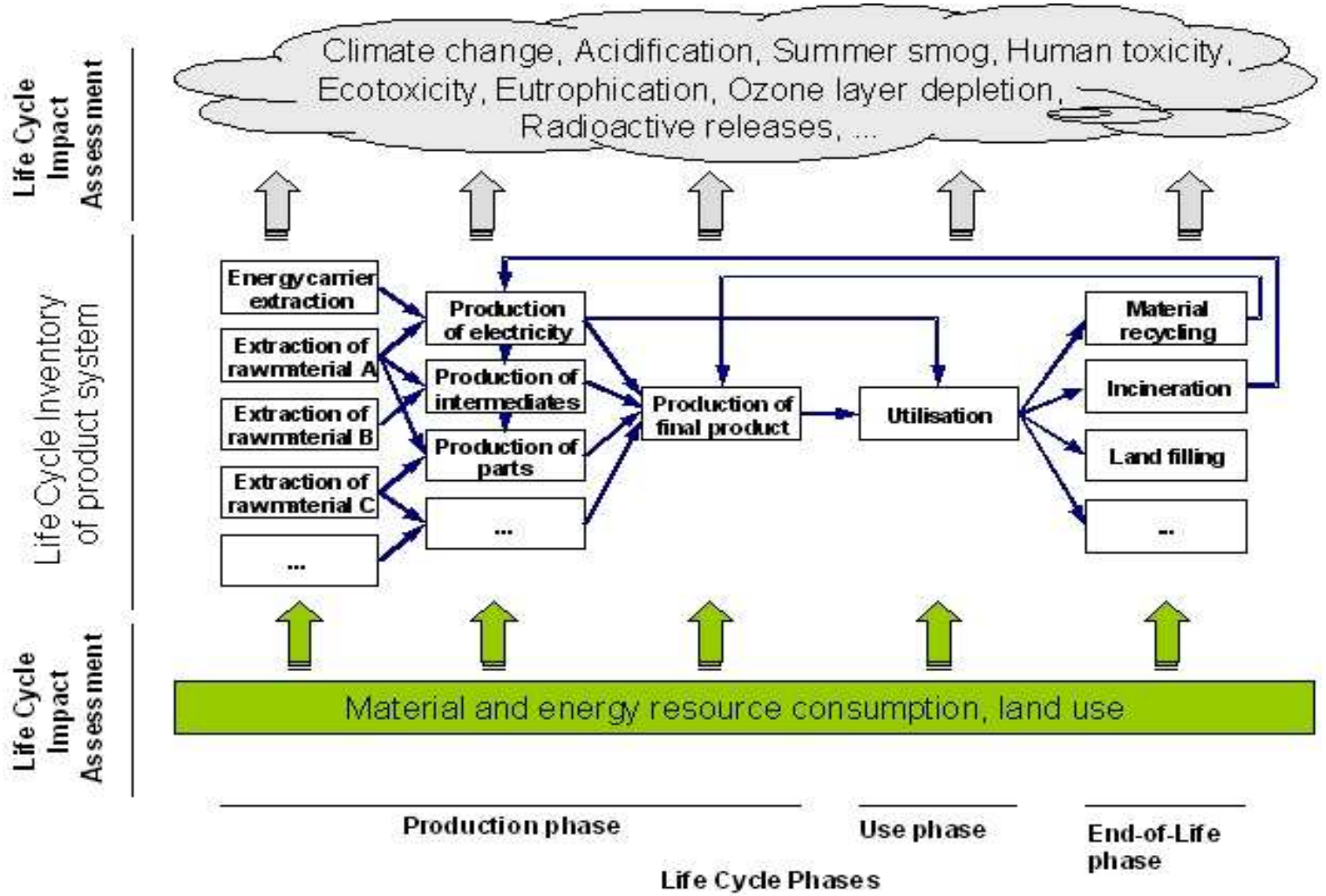
LCA in a nutshell

what is LCA?



- Environmental decision-support tool since 1970s
- Central to sustainable consumption and production (UNEP)
- Essential for a “life cycle” **(green) economy** (WSSD)
- International standard: ISO 14040 series from late 1990s

LCA in a nutshell – what is LCA?



LCA in a nutshell

Why LCA?

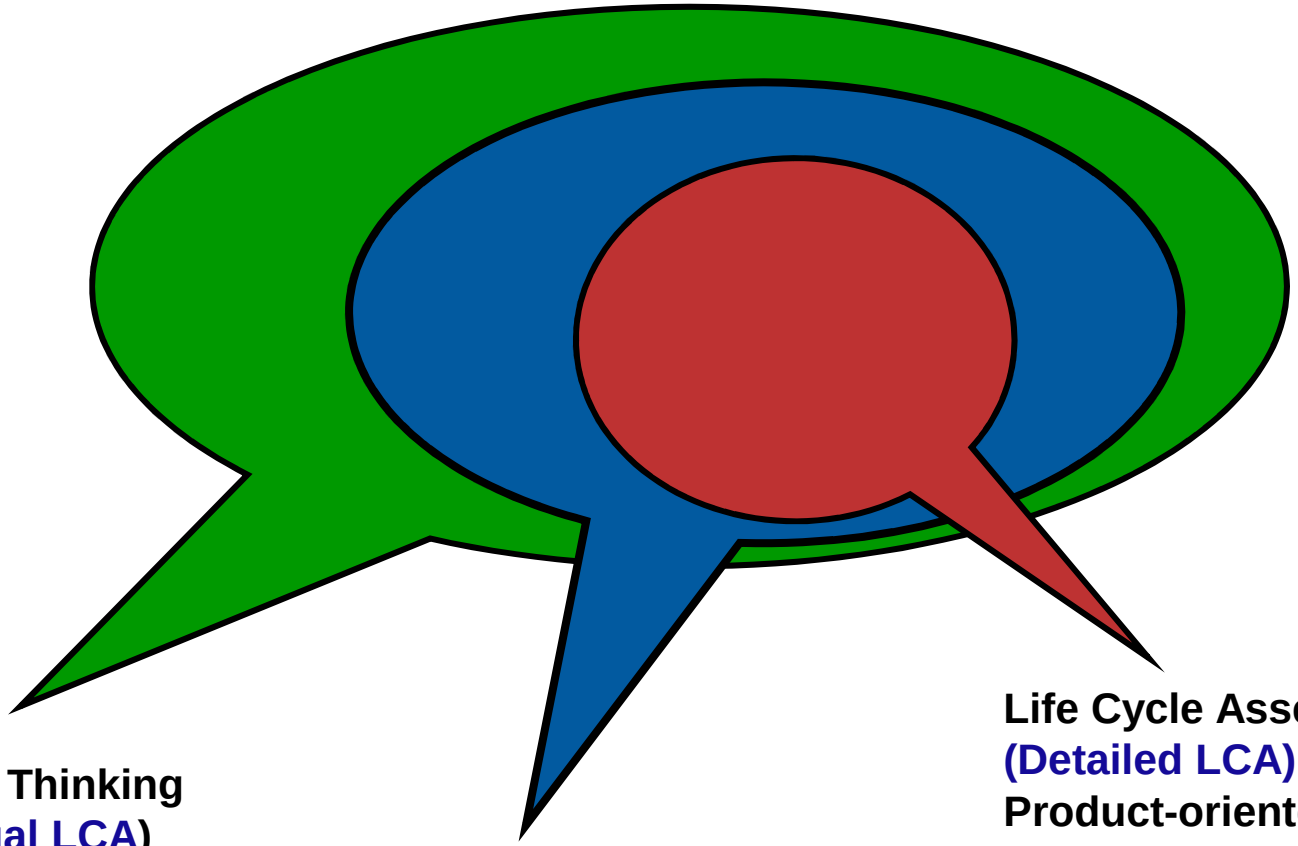
LCA principles

- Pollution prevention - 21st Century policy approach
- Systems perspective – whole life cycle (supply chain) approach
- Scientific (performance oriented) and quantitative

"Green" principles

- Pollution control "end-of-pipe" – outdated policy approach
- Fragmented perspective – dissociates product from supply chain
- Performance oriented intents versus prescriptive requirements

LCA applications



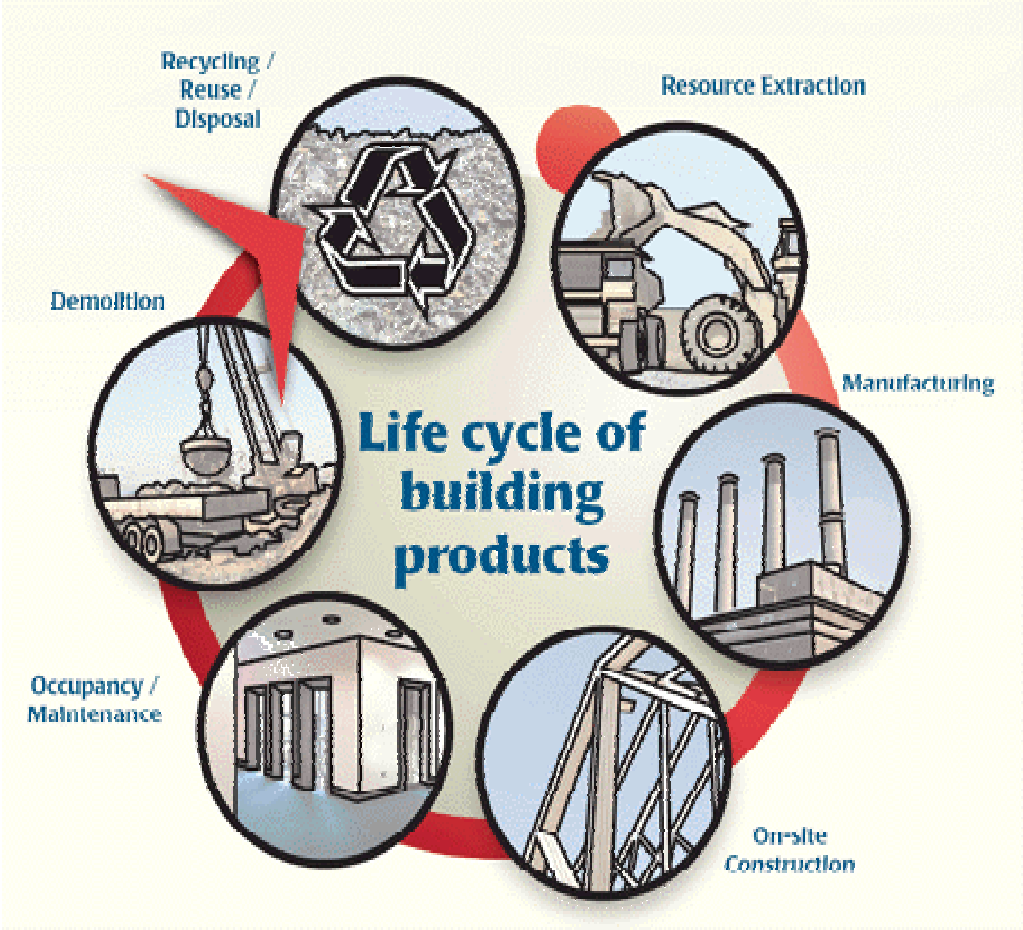
Life Cycle Thinking
(Conceptual LCA)
Product-oriented regulation e.g., IPP (DfE + CP + EPR)

Life Cycle Management
(Simple LCA)
Product-oriented industry strategies e.g., DfE, CP.

Life Cycle Assessment
(Detailed LCA)
Product-oriented decision support for industry e.g, eco-labelling

LCA applications in construction

Tools and what they do



Level 1B tools: Specification

- Materials and components e.g., BEES (North America)

Level 2 tools: design concept

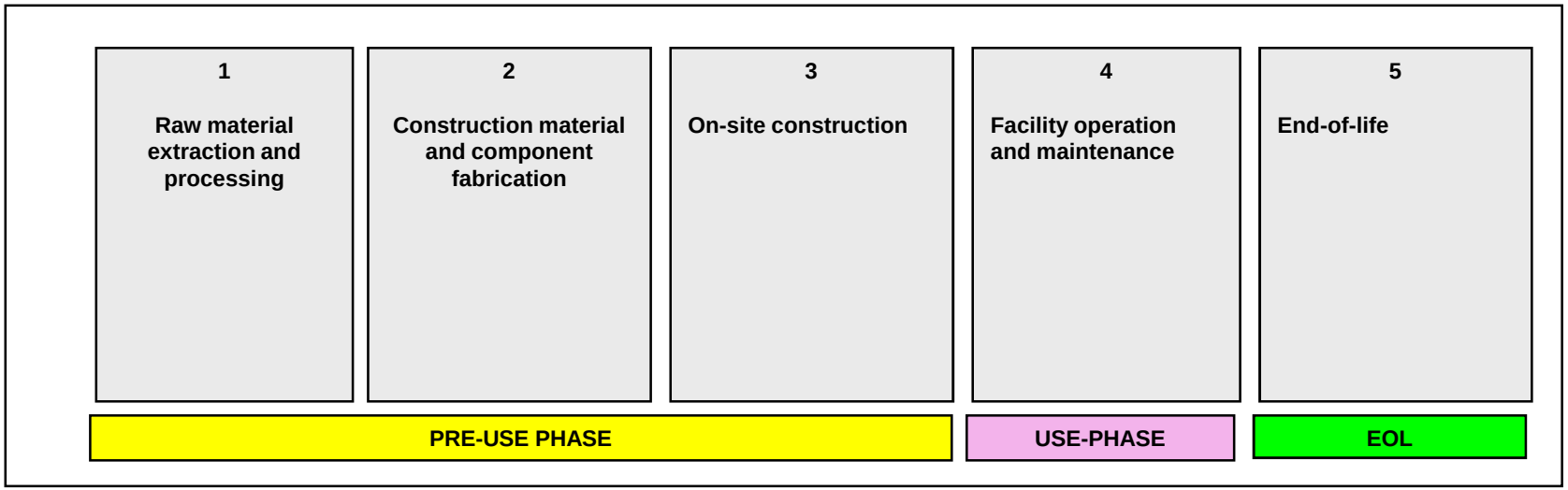
- Whole buildings and complex assemblies e.g., Athena EIE (North America)

Level 3 tools: rating/ certification

- Whole building e.g. BREEAM (UK)

Life cycle phases and environmental impacts

Construction life cycle phases and environmental impacts – energy use profile

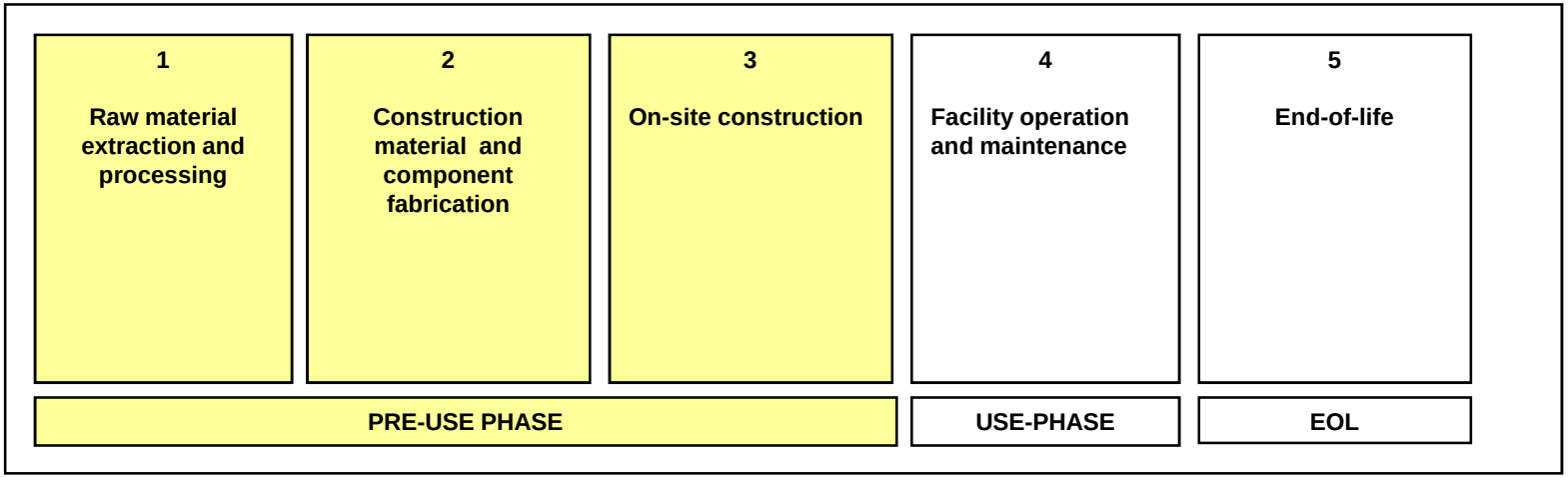


- Pre-use phase: 10-20% of total life cycle energy
- Use phase: 80-90% of total life cycle energy
- End-of-life: less than 1% of total life cycle energy

Environmental problems associated with energy use:

- Acidification, climate change, eutrophication, human toxicity, smog

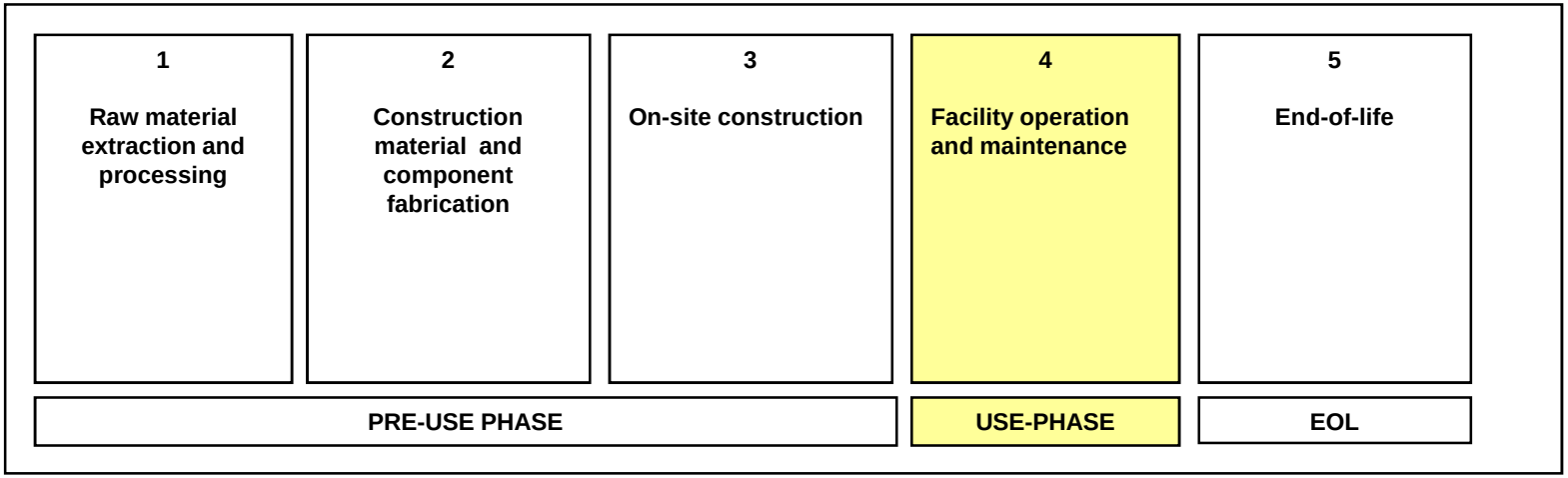
Construction life cycle phases and environmental impacts - materials use profile



Pre-use phase

- Depletion of energy (embodied + transportation)
- Depletion of virgin raw materials (extraction + construction waste)
- Land use impacts (loss of habitat, etc)
- Toxic emissions to soil and water

Construction life cycle phases and environmental impacts – materials use profile



Use phase

Service life (replacement, maintenance) is critical due to long life of buildings

Structural elements

- No replacement factor, low maintenance
- High embodied energy = lower operational energy

Non-structural elements

- High replacement and maintenance factors
- Significant impacts (materials, energy, pollution, costs)

Construction life cycle phases and environmental impacts – materials use profile

Use phase (High impact materials/ components)

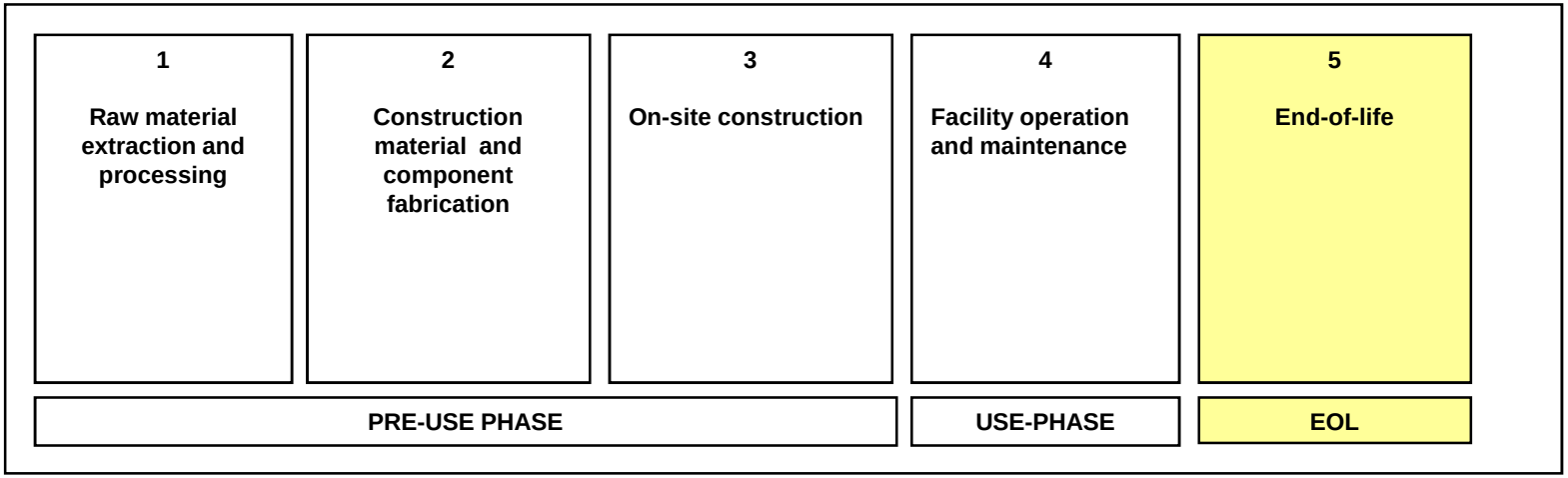
Material /component	Reasons
Steel-based products (galvanised, reinforced, etc)	High embodied energy, large quantities, high emissions
Cement-based products (concrete, plaster, render, screed)	
Carpets	High embodied energy, high emissions, frequent replacement / maintenance
Paints	
Copper products	Toxic contents (even in small quantities)
PVC flooring	

Construction life cycle phases and environmental impacts – materials use profile

Use phase (service life considerations)

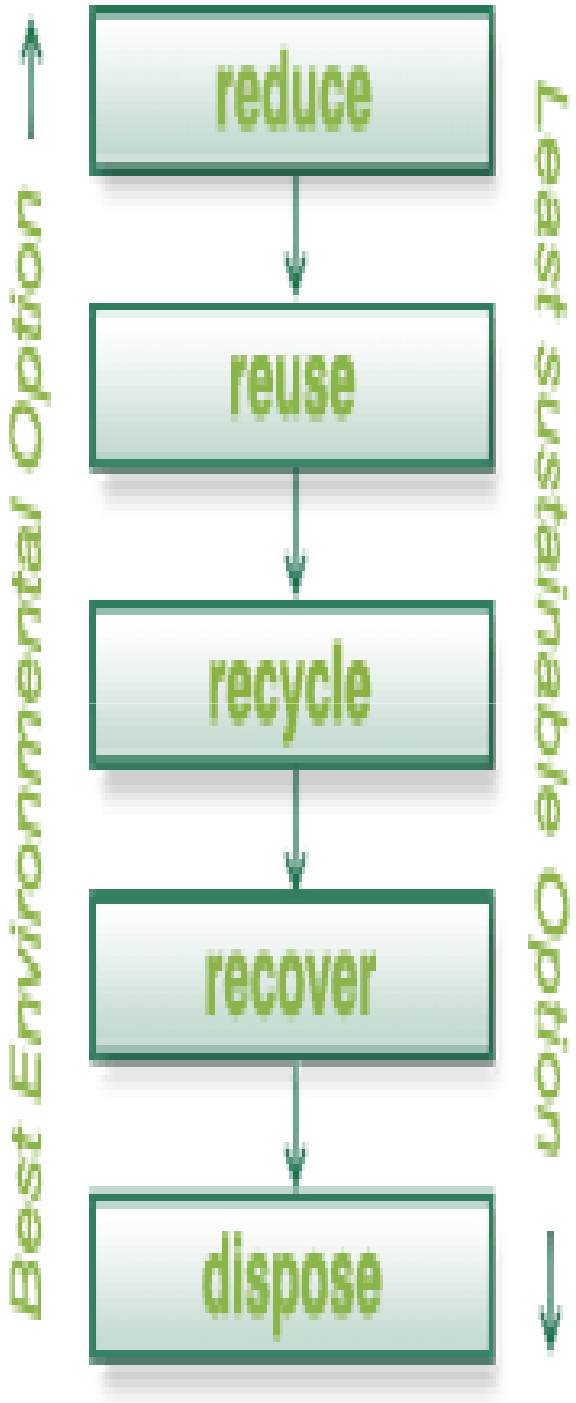
Material /component	Assumed service life (years)
Bricks and blocks	50
Concrete	50
Structural steel	50
Roof assembly	15
Carpet	10
Paint	10

Construction life cycle phases and environmental impacts – materials use profile



End-of-life phase

- Approximately 90% of extracted stock of materials may be contained in the built environment, making it a potential future resource, or alternatively, a potential future source of waste



Construction life cycle phases and environmental impacts – materials use profile

End-of-life phase

Key challenges

- No waste management hierarchy – even **"green"** buildings are not designed for de-coupling or disassembly
- Landfilling = wasted materials + embodied energy

Environmental consequences

- Resource depletion (energy and materials)
- Land use impacts
- Pollution – soil and water

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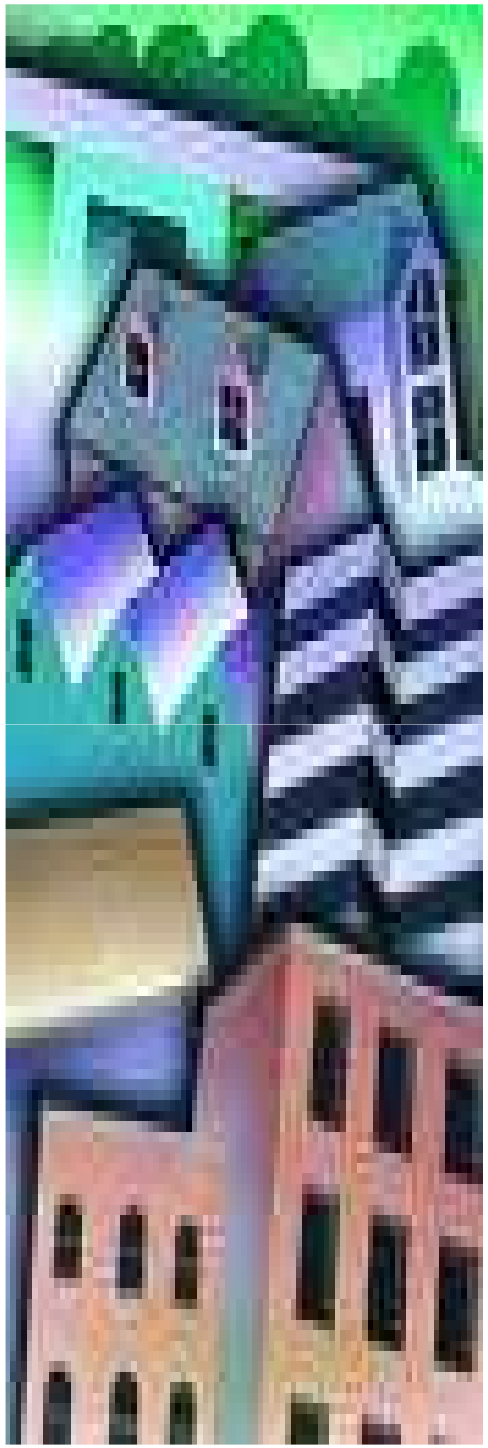

LCA limitations

LCA is not the answer to all material-related problems. Does not easily address:

- Indoor environmental quality
- Land-use impacts
- Uncertainty and risks related to toxic releases

LCA barriers

- Accessibility and availability of life cycle inventory (LCI) data
- Mindset – dominance of prescriptive “green” approaches

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LCA-based considerations for materials selection

LCA-based considerations for materials selection

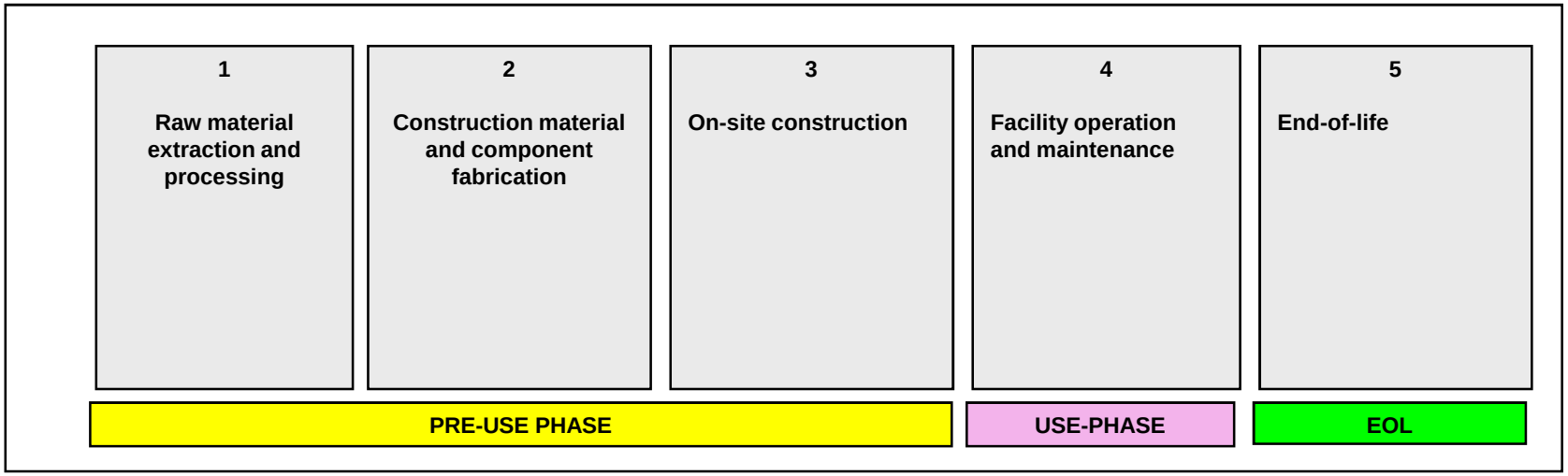
The reality

- Environmentally sustainable **(green)** materials *do have* environmental impacts

- **"Green"** materials function in systems – the supply chain, from materials production to green building certification needs to go "green"

- Meeting regulatory requirements – e.g. Waste Management Bill, carbon taxes, etc has shifted from subjective to objective, science-based data

LCA-based considerations for materials selection



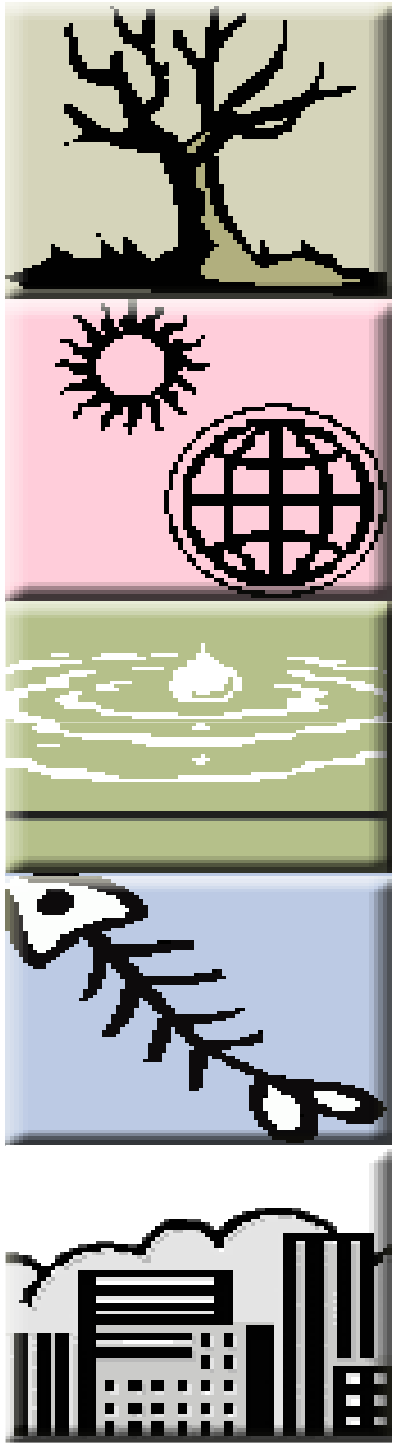
Select "**green**" materials in consideration of trade-offs:

- Multiple life cycle stages and phases; and
- Material combinations which reduce long-term impacts

LCA-based considerations for materials selection

Select **“green”** materials in consideration of multiple environmental inputs:

- Materials
- Energy
- Water
- Land



LCA-based considerations for materials selection

Select **“green”** materials in consideration of their contribution to multiple environmental issues of concern to society, i.e.,

- Acidification
- Climate change
- Eutrophication
- Ecotoxocity
- Human toxicity
- Stratospheric ozone depletion
- Photochemical Oxidant formation

Questions??

Thank you