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PUB-WOOD

Life Cycle Analysis

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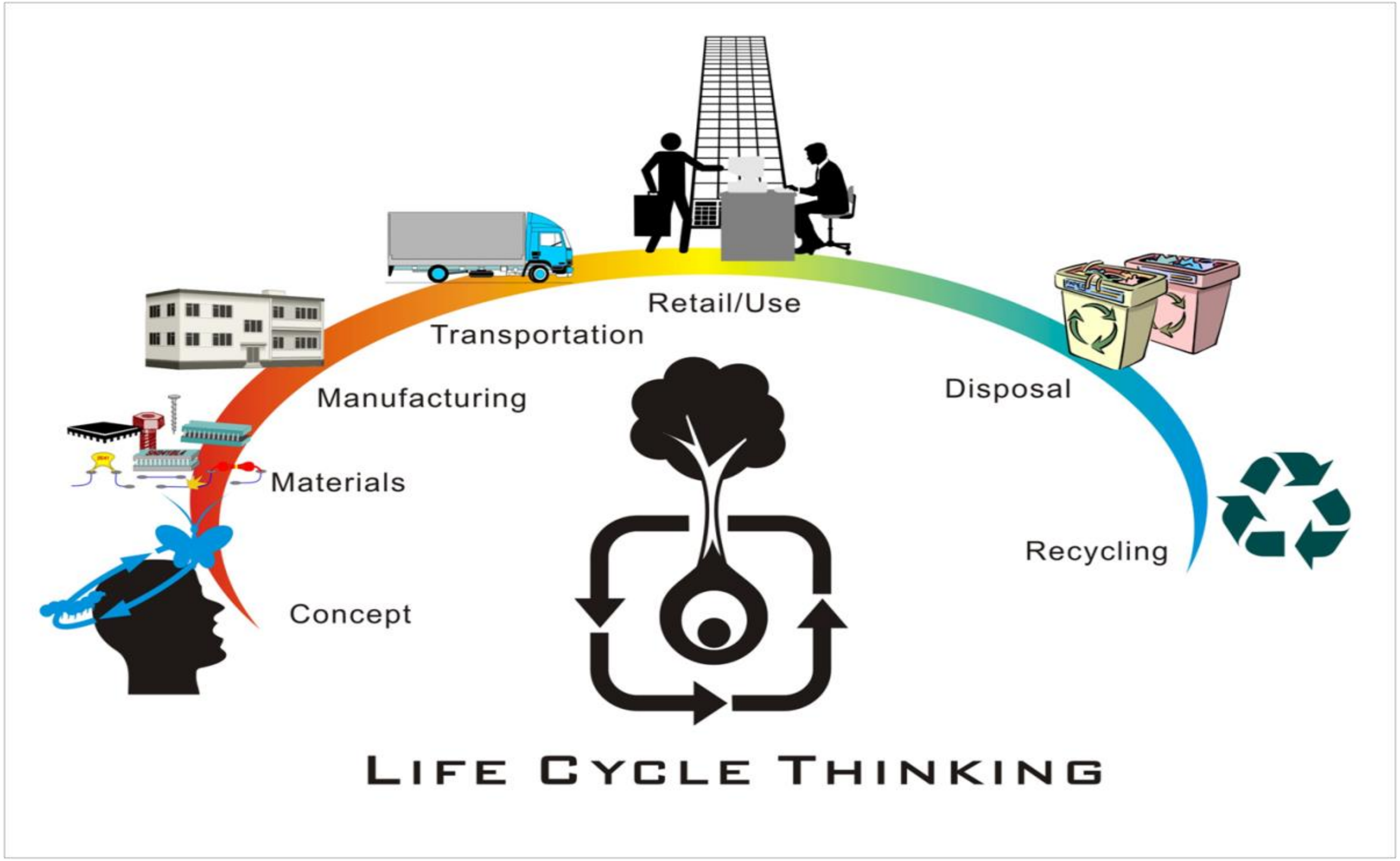
Life cycle thinking



Source: https://systemsthinkingdesign.wordpress.com/2013/08/18/what-is-life-cycle-thinking/

Life Cycle Thinking

“Life Cycle Thinking is a way of thinking that includes the economic, environmental and social consequences of a product or process over its entire life cycle” (UN Environment Programme Life Cycle Initiative)

Life Cycle Thinking helps enterprises to understand and improve their environmental performance and social performance, while maintaining or improving profits.

Life Cycle Assessment (LCA) is:

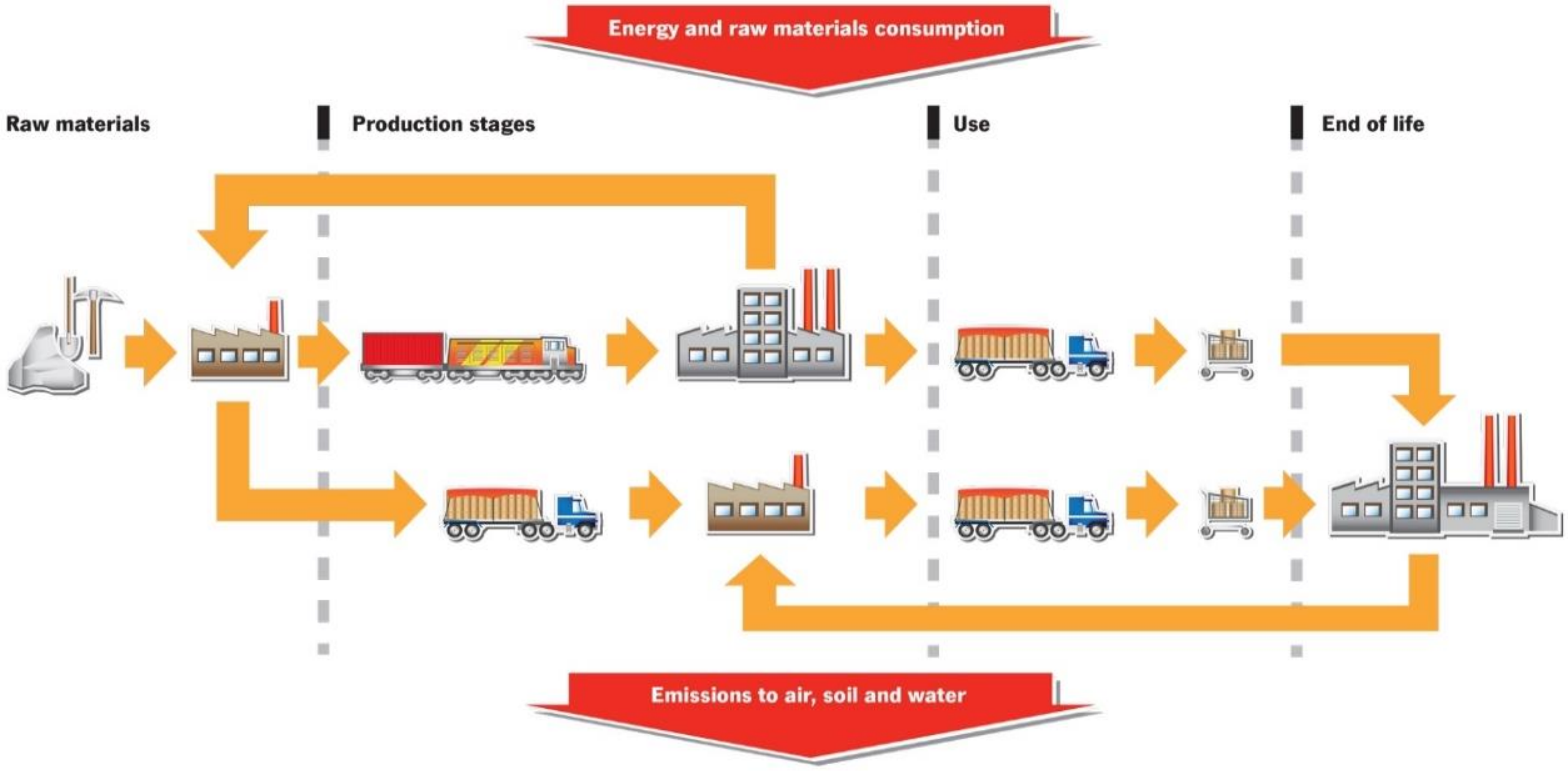
- «Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle» (Aravind Samala, 2017)
- A tool for systematic evaluation of the environmental impact of a product throughout each stage of its life cycle
- Also called Life Cycle Analysis, Eco balance or Cradle to Grave Analysis
- It considers all the environmental impacts from the extraction of raw material to its final disposal. (Om Kumar Agnihotri, 2015)

Life Cycle Assessment is:

- "a technique for assessing the environmental aspects and potential impacts associated with product, system or service"

(ISO 14040:2006, The International Organization for Standardization)

Life Cycle Assessment looks at impacts across the life of a product, rather than just one part (such as end of life)



Source: https://www.branz.co.nz/cms_display.php?sn=308&st=1&pg=16913

What is your life story?

- When and where were your parents married?
- Where are you from?
- What were your hobbies, when you were 7 years old?
- Where did you move when you were 10?

You can tell your life story!

- Where do you want to be 5 years from now on?

- Imagine this doing for a product…
- Life cycle assessment will tell you the product`s life story

Life cycle stages

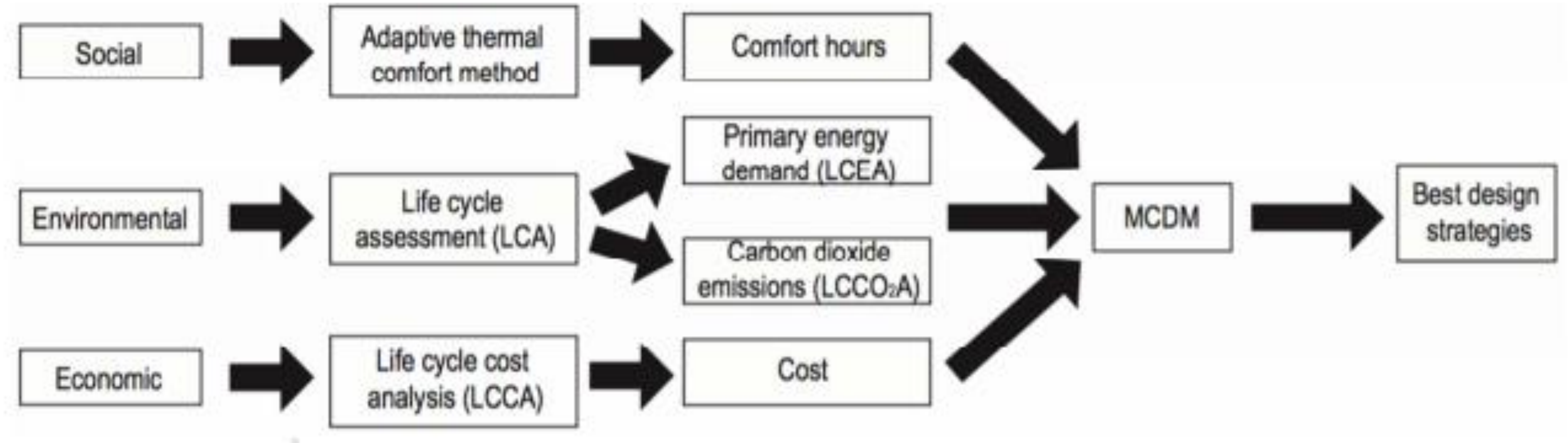
Source: https://www.innovationservices.philips.com/news/life-cycle-assessment-finding-best-approach-company/

What does LCA do?

- Life Cycle Assessment looks at environmental impacts across the main life cycle stages to see where the «hot spots» are!
- LCA allows us to see:
  - **TRUE** environment impacts across entire system;
  - Where environmental impacts occur across the entire system.
- Environmental «Folklore»:
  - The assumptions we make about what is ‘green’ and what is not
  - Usually based on our experiences, upbringing, media, education etc.
  - Not usually based on scientific understanding
  - Often leads to impact transfer not impact reduction

(Leyla Acaroglu, 2011)

LCA in context of sustainable development



*MCDM – multi-criteria decision making

Source: Andrea Invidiata, Monica Lavagna, Enedir Ghisi, 2018

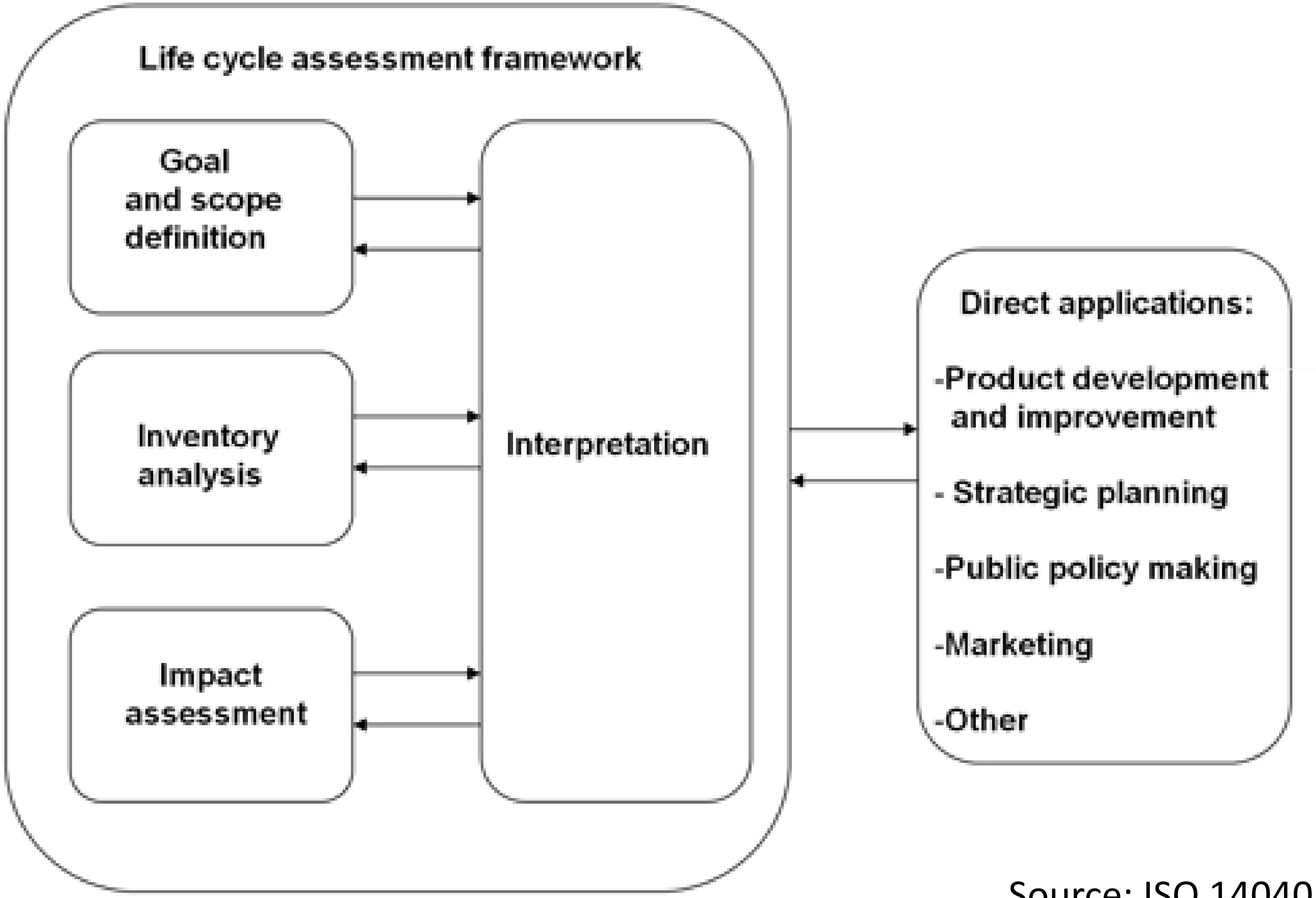
LCA Framework

The LCA process is a systematic, phased approach and consists of four components:

- *Goal Definition and Scoping* – Define and describe the product, process or activity. Establish the context in which the assessment is to be made and identify the boundaries and environmental effects to be reviewed for the assessment.
- *Inventory Analysis* – Identify and quantify energy, water and materials usage and environmental releases
- *Impact Assessment* – Assess the potential human and ecological effect of energy, water, and material usage and the environmental releases identified in the inventory analysis.
- *Interpretation* – Evaluate the results of the inventory analysis and impact assessment to select the preferred product, process or service with a clear understanding of the uncertainty and the assumptions used to generate the results.

(Mary Ann Curran, 2006)

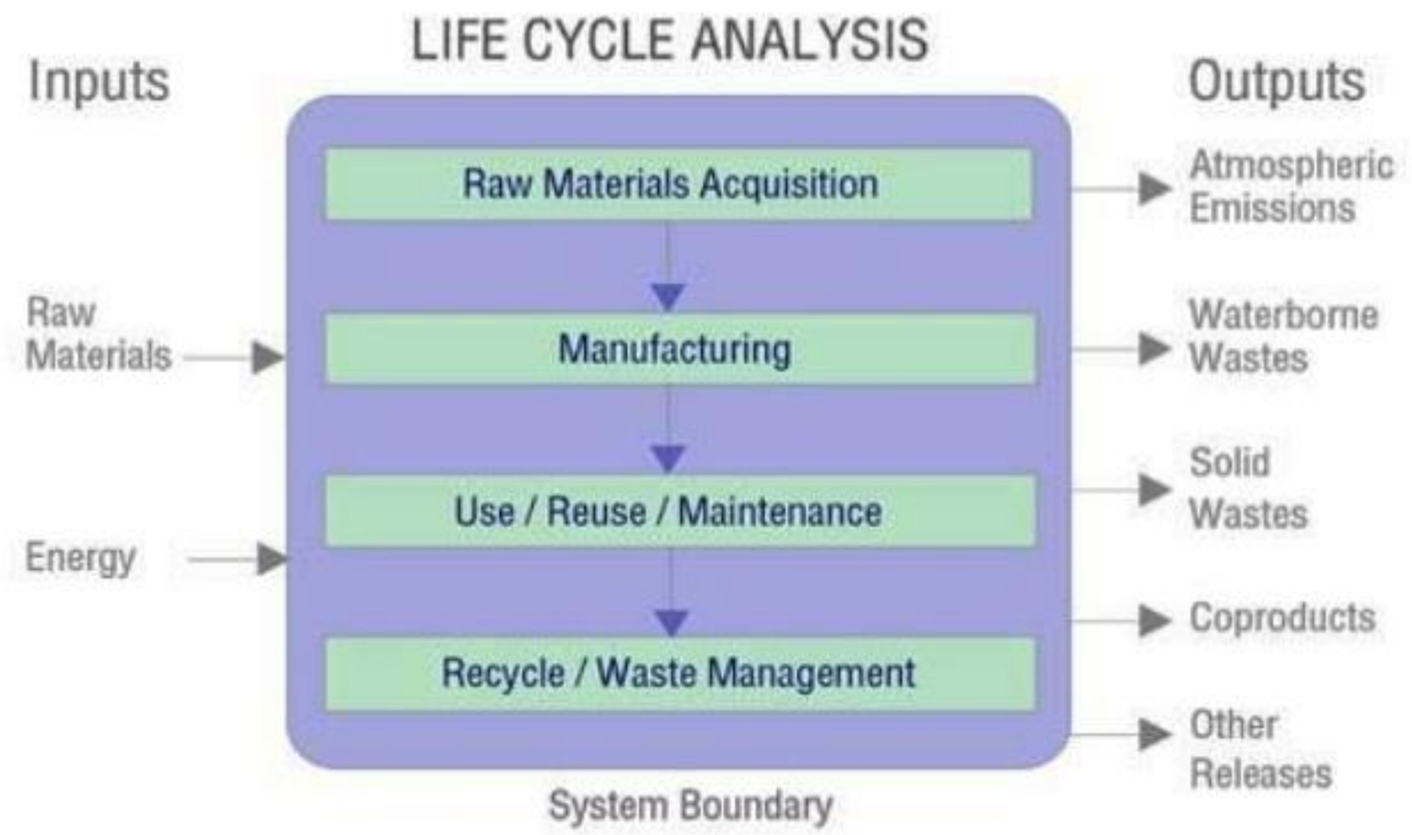
LCA Framework



Source: ISO 14040:2006

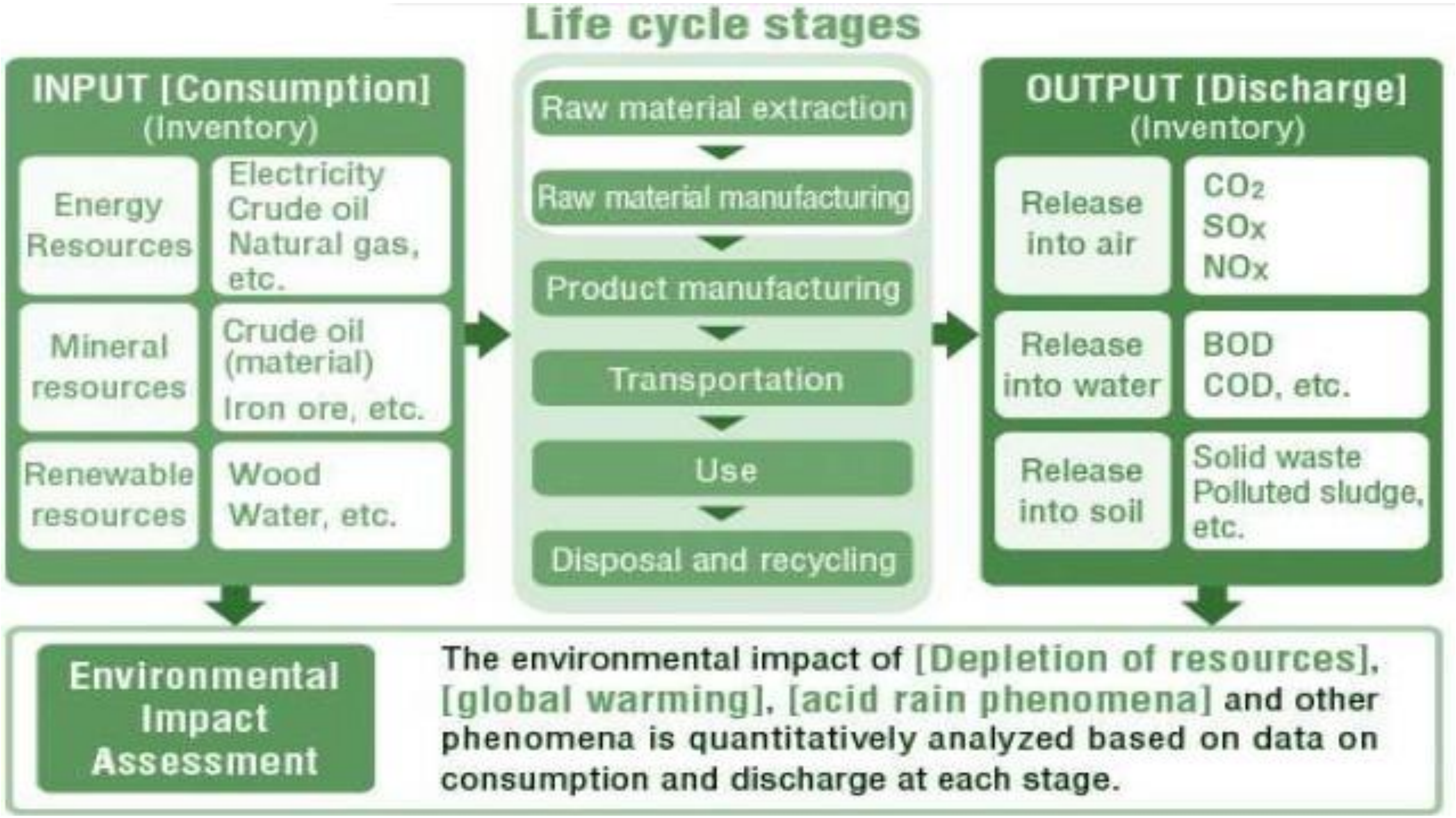
Inventory Analysis - Inputs and Outputs

- Identify and quantify energy, water and materials usage and environmental releases



Source: Om Kumar Agnihotri, 2015

Detailed example of Inventory Analysis



Source: Om Kumar Agnihotri, 2015

Impact fields

Impacts can be assessed in different fields:

- Environment, focusing on siting, energy consumption, water usage, and material usage;
- Economic, following the life-cycle costing scheme;
- Social;
- Safety and industrial risk prevention;
- Functionality;
- Aesthetics.

Source: Emanuele Bonamente, Franco Cotana, 2015

Common Impact Categories

- Land use
- Carbon emissions
- Water use
- Toxicity
- Biodiversity loss
- Extinction of species
- Habitat destruction
- Smog
- Ozone depletion
- Air pollution
- Eutrophication
- Acidification
- Formation of photochemical oxidants
- The list goes on…

Source: https://www.gsb.stanford.edu/insights/what-would-it-really-cost-reduce-carbon-emissions

Source: Leyla Acaroglu, 2011

Impact Assessment – Common Impact Categories

Impact Category	Indicator Measurement
Resources	kg Scarce Resources
Water	m^3 Water
Global Warming	kg CO_2 equivalents
Ozone Depletion	CFC-11 equivalents
Acidification	kg SO_2 equivalents
Eutrophication	kg PO_4^{3-} equivalents
Smog Formation	kg Ethene equivalents
Human Toxicity	HTx equivalents
Eco Toxicity	ETx equivalents
Waste	kg Waste
Land Use	hectares

(Dolores Gómez-López, Silvia Martínez, María Gabarrón, Ángel Faz, 2018)

Global warming

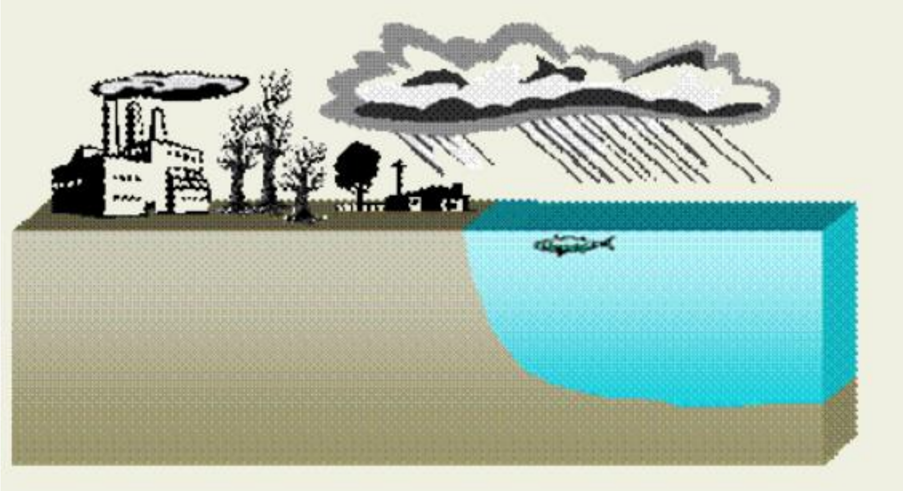
- Climate change can result in adverse affections upon ecosystem health, human health and material welfare. Climate change is related to emissions of greenhouse gases in the air. The characterization model as developed by the Intergovernmental Panel on Climate Change (IPCC) is selected for development of characterization factors. Factors are expressed as Global Warming Potential for time horizon 100 years (GWP100), in kg carbon dioxide eq. The geographic scope of this indicator is at global scale.

(Dolores Gómez-López, Silvia Martínez, María Gabarrón, Ángel Faz, 2018)

Acidification

- Acidifying substances cause a wide range of impacts on soil, groundwater, surface water, organisms, ecosystems and materials (buildings). Acidification Potential is expressed as kg SO_2 equivalent. The time span is eternity and the geographical scale varies between local scale and continental scale.

(Dolores Gómez-López, Silvia Martínez, María Gabarrón, Ángel Faz, 2018)



Source: http://qpc.adm.slu.se/7_LCA/page_10.htm

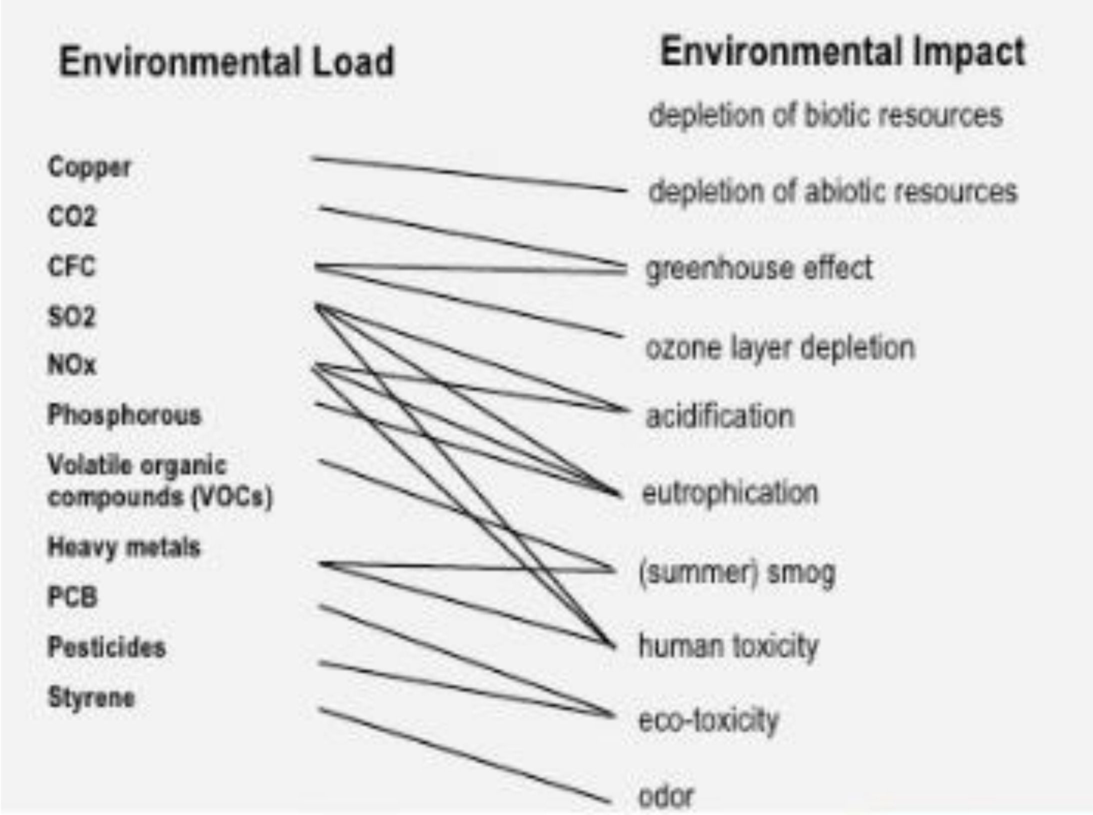
Eutrophication

- Also known as nitrification. It includes all impacts due to excessive levels of macro-nutrients in the environment caused by emissions of nutrients to air, water and soil. Nitrification potential (NP) is expressed as kg PO_4 equivalents. Time span is eternity, and the geographical scale varies between local and continental scale.

(Dolores Gómez-López, Silvia Martínez, María Gabarrón, Ángel Faz, 2018)

Impact Analysis

1. Define impact categories
2. Determine which loads affect different impact categories
3. Assign indicators to impact categories
4. Weigh importance of each category



(Hector Rodriguez, 2010)

Example -coffee maker

Production (Materials, treatments, transport and extra energy)

material or process	amount	indicator	result
polystyrene	1 kg	360	360
injection moulding PS	1 kg	21	21
aluminium	0,1 kg	780	78
extrusion Al	0,1 kg	72	7
steel	0,3 kg	86	26
glass	0,4 kg	58	23
gas-fired heat (forming)	4 MJ	5,3	21
Total [mPt]			536

Use (Transport, energy and possible auxiliary materials)

process	amount	indicator	result
electricity low-voltage	375 kWh	37	13.875
paper	7,3 kg	96	701
Total [mPt]			14.576

Disposal (Disposal processes for each material type)

material and type of processing	amount	indicator	result
municipal waste, PS	1 kg	2	2
municipal waste, ferrous	0,4 kg	-5,9	-2,4
household waste, glass	0,4 kg	-6,9	-2,8
municipal waste, paper	7,3 kg	0,71	5,2
Total [mPt]			2
Total [mPt] (all phases)			15.114

Source: https://www.pre-sustainability.com/download/EI99_Manual.pdf

Improvement analysis

- Identify areas & opportunities for improvement
- Evaluate progress versus original goal definition
- Target lifecycle areas/processes/events with large impacts
  - Large amounts with low hazard
  - Small amounts with high hazard
- Ask yourself:
  - What are the resources required and risks involved?

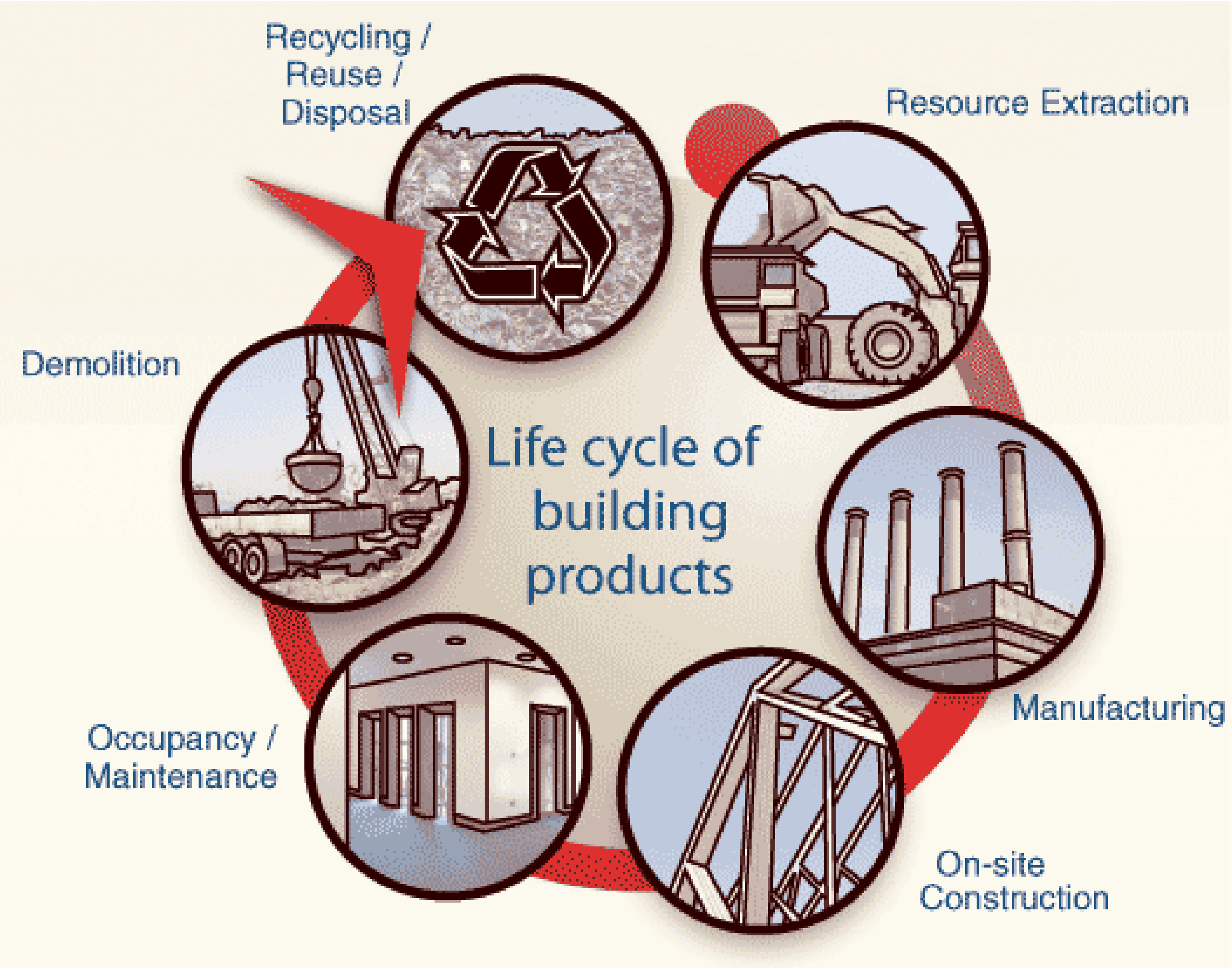
(Hector Rodriguez, 2010)

Buildings

- Buildings became a major target for environmental improvement as building sector accounted for nearly
  - 40% of the world`s energy consumption,
  - 30% of raw material use
  - 33% of the related global greenhouse gas emissions

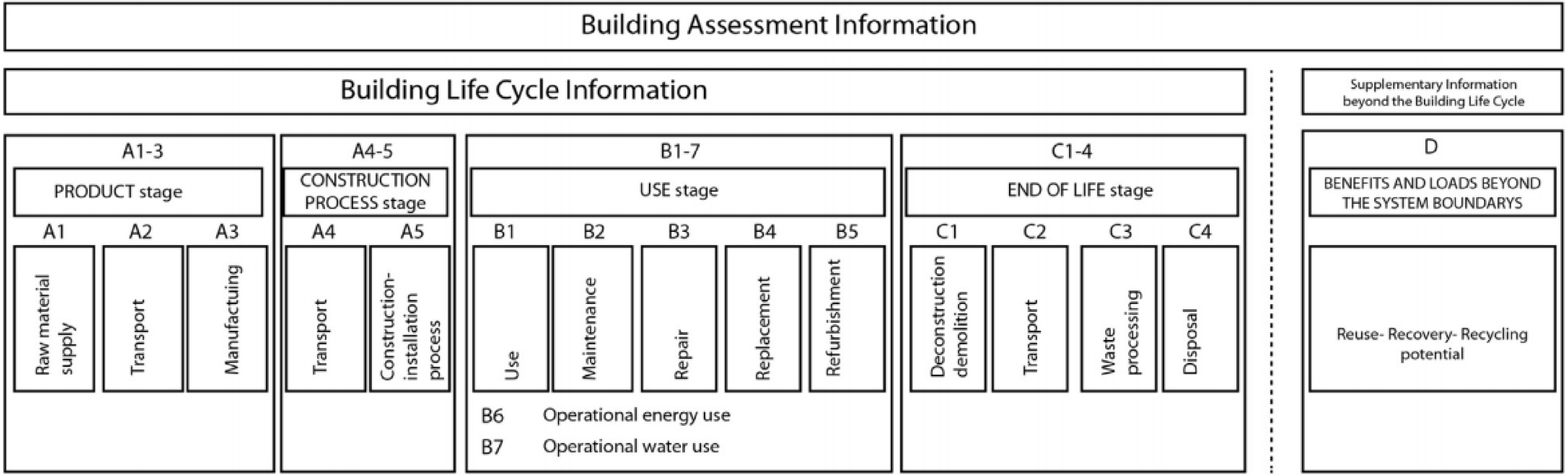
(Aravind Samala, 2017)

Building life cycle



Source: http://www.woodworks.org/sustainable-design/lca/

Building Assessment Modules for Life Cycle Assessment



Source: Alberto Vilches, Antonio Garcia-Martinez, Benito Sanchez-Montanes, 2017

Carbon storage in wooden products

- Wood material is composed of about 50% carbon by dry weight, this carbon coming from the CO_2 removed from the atmosphere by the growing tree. In other words, wood products provide a physical storage of carbon that was previously in the atmosphere as a GHG (Lippke et al ., 2010).

Wood-based vs. non-wood materials

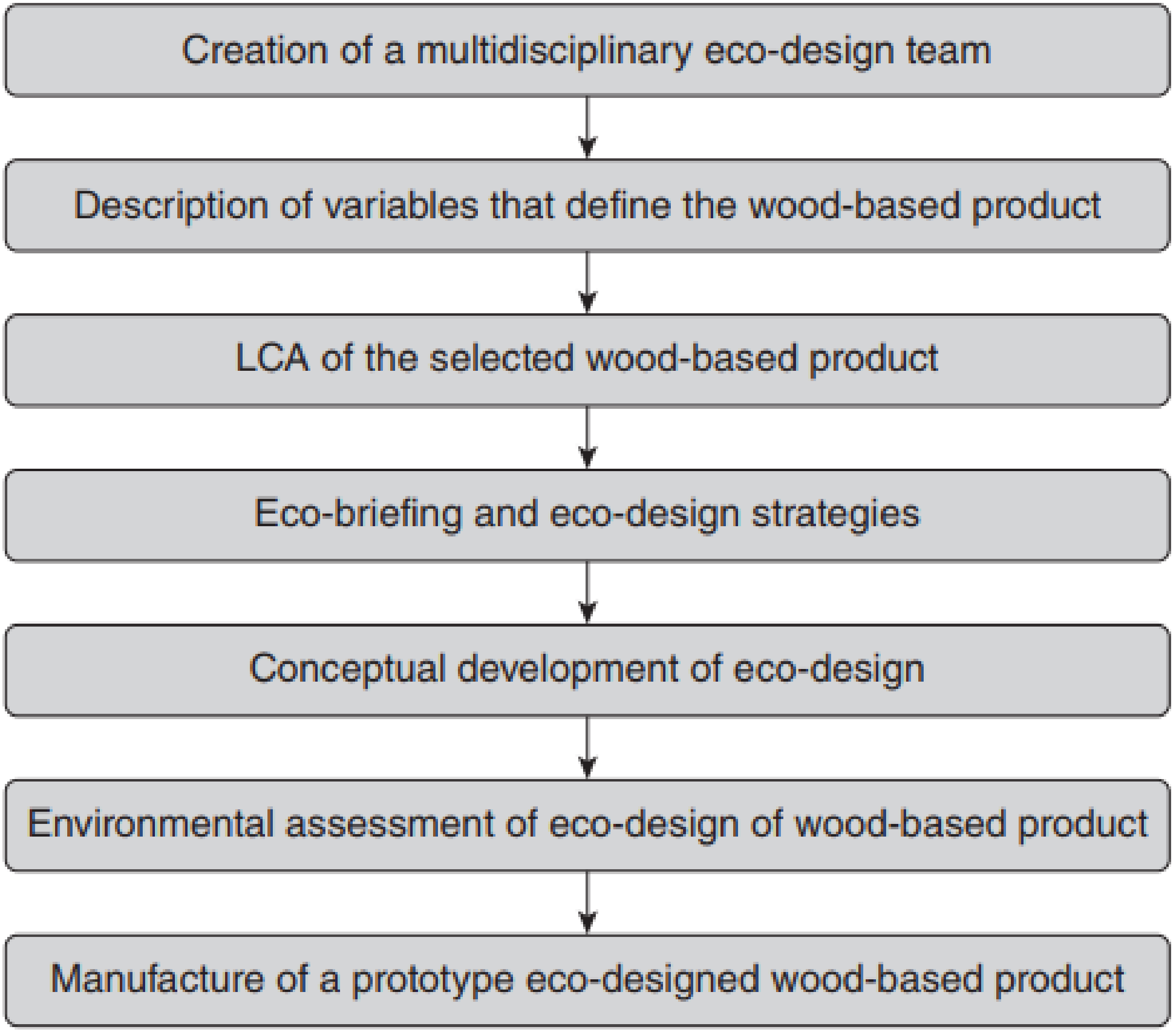
- «A general conclusion of comparative studies of wood-based vs. non-wood materials is that wood products **from sustainably managed forests** have the potential to produce significantly less life cycle environmental impact than other common building materials such as concrete and steel» (Werner and Richter, 2007 ; Sathre and O’Connor, 2010a).
- The environmental impacts of many such construction components have been quantified in recent years, generally showing that **wood-based components have lower overall impacts than comparable products made of non-wood materials** (Werner and Richter, 2007; Sathre and O’Connor, 2010a)
- «A general conclusion of comparative studies is that **wood-based construction systems tend to have lower environmental impacts than functionally equivalent systems using non-wood materials**» (Werner and Richter, 2007 ; Sathre and O’Connor, 2010a).

Eco-design

- Eco-design, or Design for the Environment (DfE), is a concept that integrates **multifaceted aspects of design** and environmental considerations. The development of sustainable solutions for products or services is based on the minimization of negative consequences under economic, environmental and social perspectives, throughout and beyond the life cycle of products (R.Sathre, S. González-García, 2014)
- Ecodesign is an approach to designing product with special consideration for the environmental impacts of the product during its whole lifecycle. In a life cycle assessment, the life cycle of a product is usually divided into procurement, manufacture, use, and disposal. Ecodesign is a growing responsibility and understanding of our ecological footprint on the planet. Green awareness, overpopulation, industrialization and an increased environmental population have led to the questioning of consumer values. It is imperative to search for new building solutions that are environmentally friendly and lead to a reduction in the consumption of materials and energy.

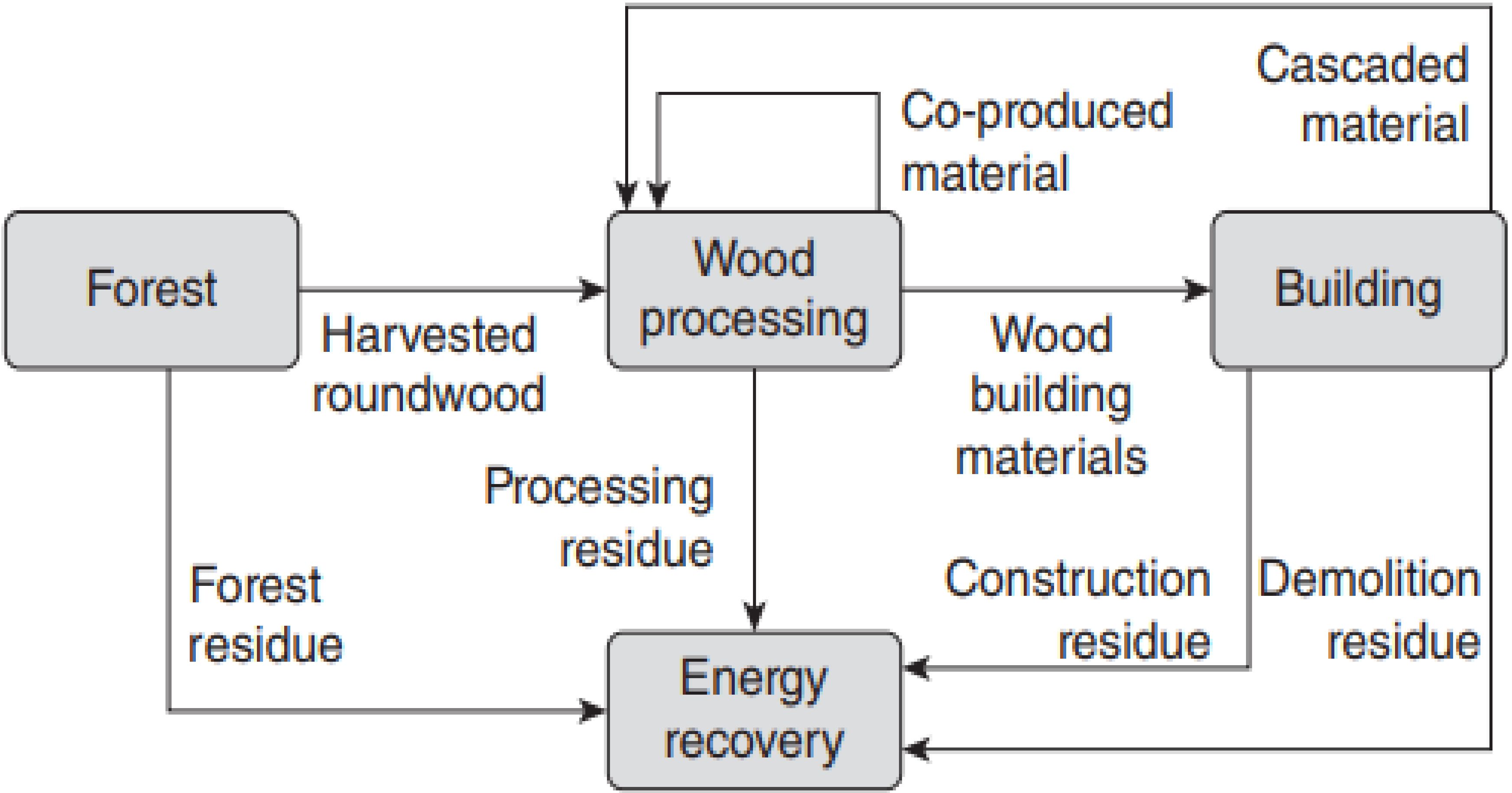
Source: https://www.definitions.net/definition/ecodesign

Stages in the methodology for the eco-design of a wood-based product



Source: R. Sathre, S. González-García, 2014

Schematic diagram of potential biomass flows during the life cycle of wood building material



Source: R. Sathre, S. González-García, 2014

Cascading

- A strategy to increase the efficiency of resource use (Haberl and Geissler, 2000).
- Cascading is the sequential use of a resource for different purposes, as the resource quality degrades over time.
- The cascade concept includes four dimensions of resource economy:
- resource quality,
- utilization time,
- salvageability,
- consumption rate (Sirkin and ten Houten, 1994).

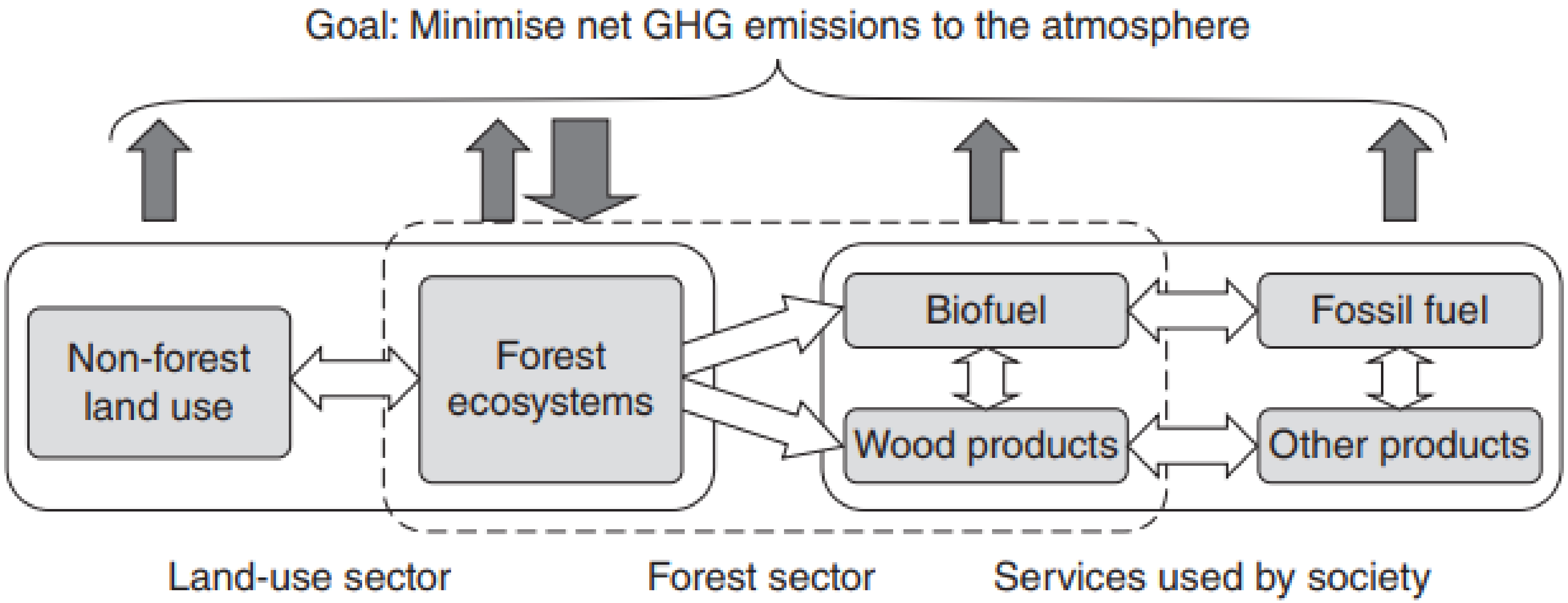
Source: R. Sathre, S. González-García, 2014

Optimal utilization of wood resources:

- matching the resource quality to the task being performed, so as not to use a high-grade resource when a lower-grade one will suffice;
- increasing the total utility gained from a resource through prolonging the time during which it is used for various purposes;
- upgrading a resource through salvaging and reprocessing, where appropriate, for additional higher-grade uses;
- balancing the usage rate of a resource with the capacity of forest land to regenerate lost resource quality.
- A simple form of cascading is to burn a wood product at the end of its useful service life and recover the heat energy.
- «..**when forest resources are limited**, it will be beneficial to employ a more complex cascade chain involving multiple material uses before final burning» (Sathre and Gustavsson, 2006).

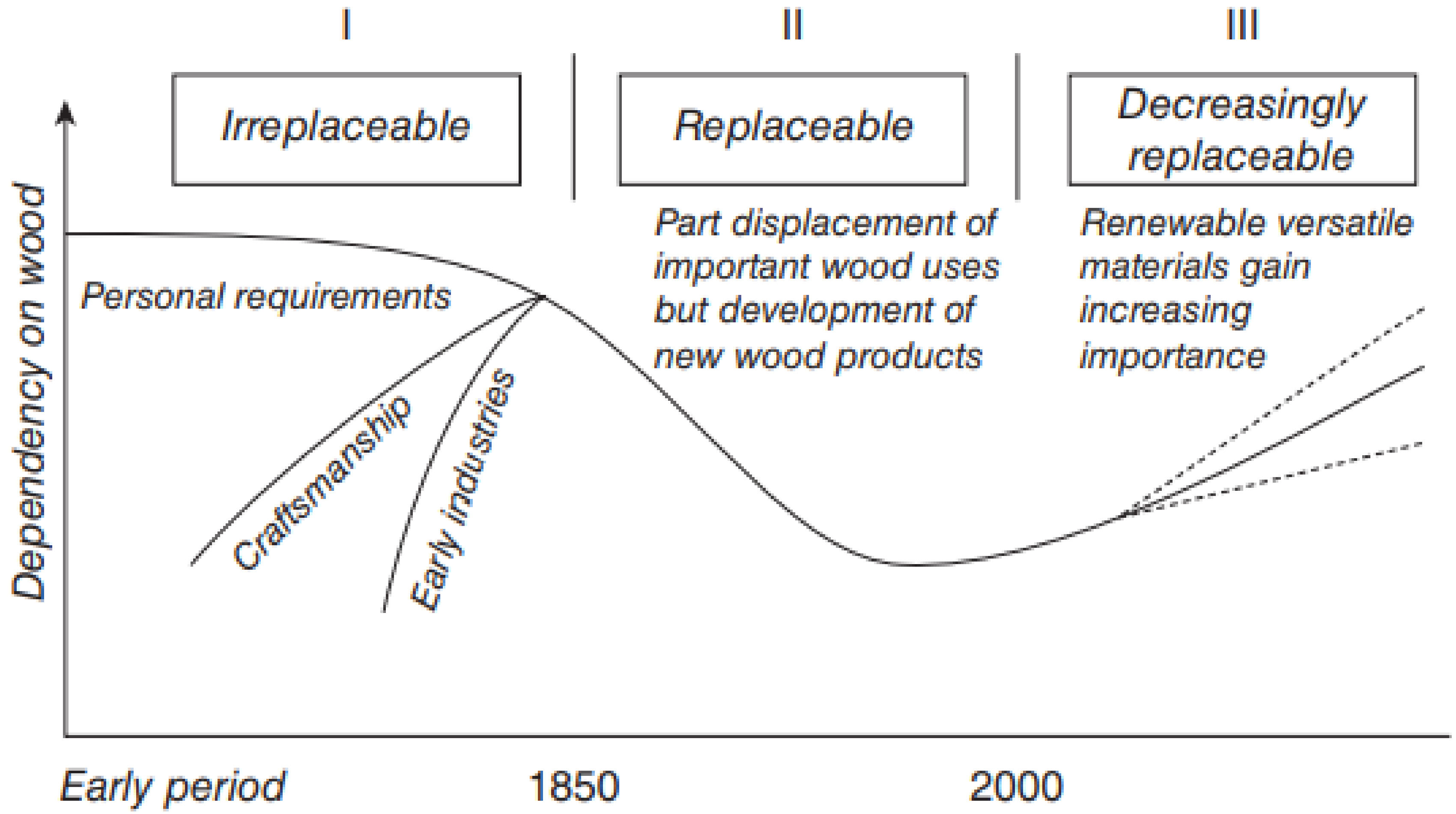
Source: R. Sathre, S. González-García, 2014

Linkages between the forest sector and other sectors, with the overall goal of minimizing net GHG emission to the atmosphere



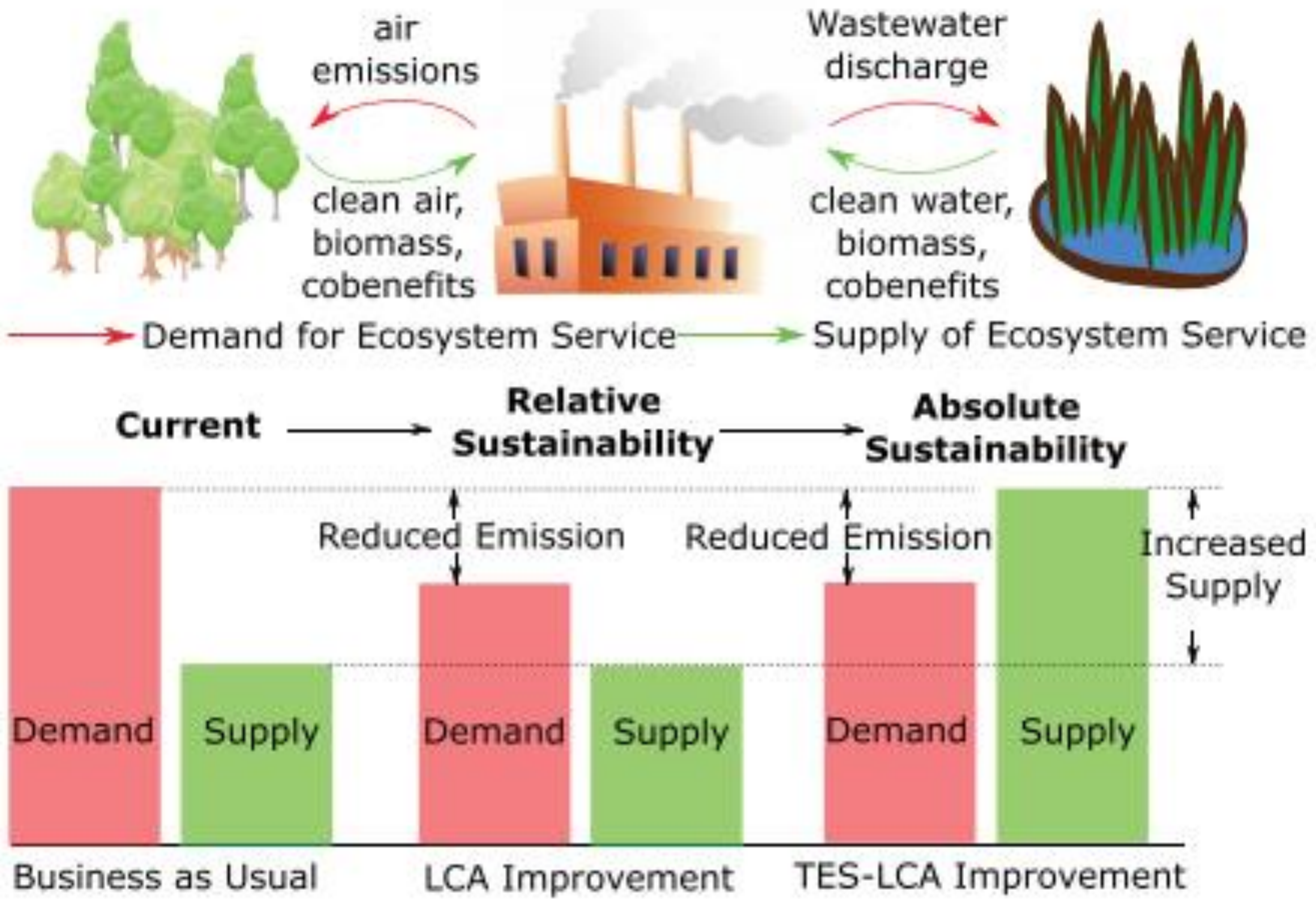
Source: R. Sathre, S. González-García, 2014

Relative importance of wood material in past, present, and future



Source: Sathre and Gustavsson, 2009; Schulz, 1993

Benefits of LCA improvement



Source: Xinyu Liu, Bhavik R. Bakshi, 2018

Summary

- Life Cycle Assessment is a scientific process.
- It is about whole life of a product, system, service.
- LCA is Looking at things that come in and go out of the system and how they interact with environment.
- Focus should be on product`s lifecycle, not the product itself.
- Life cycle and system perspectives of the built environment are needed, so that all the life cycle phases – production, operation, maintenance and end-of-life – are considered and optimized as a whole, including the energy and material chains from natural resources to final services.

Sources: Leyla Acaroglu, 2011, Hector Rodriguez, 2010, R. Sathre, S. González-García, 2014

Thank you for attention!