THE UNIVERSITY OF BRITISH COLUMBIA

ENGR 544, Life Cycle Assessment and Management

School of Engineering, Faculty of Applied Science

The University of British Columbia (Okanagan)

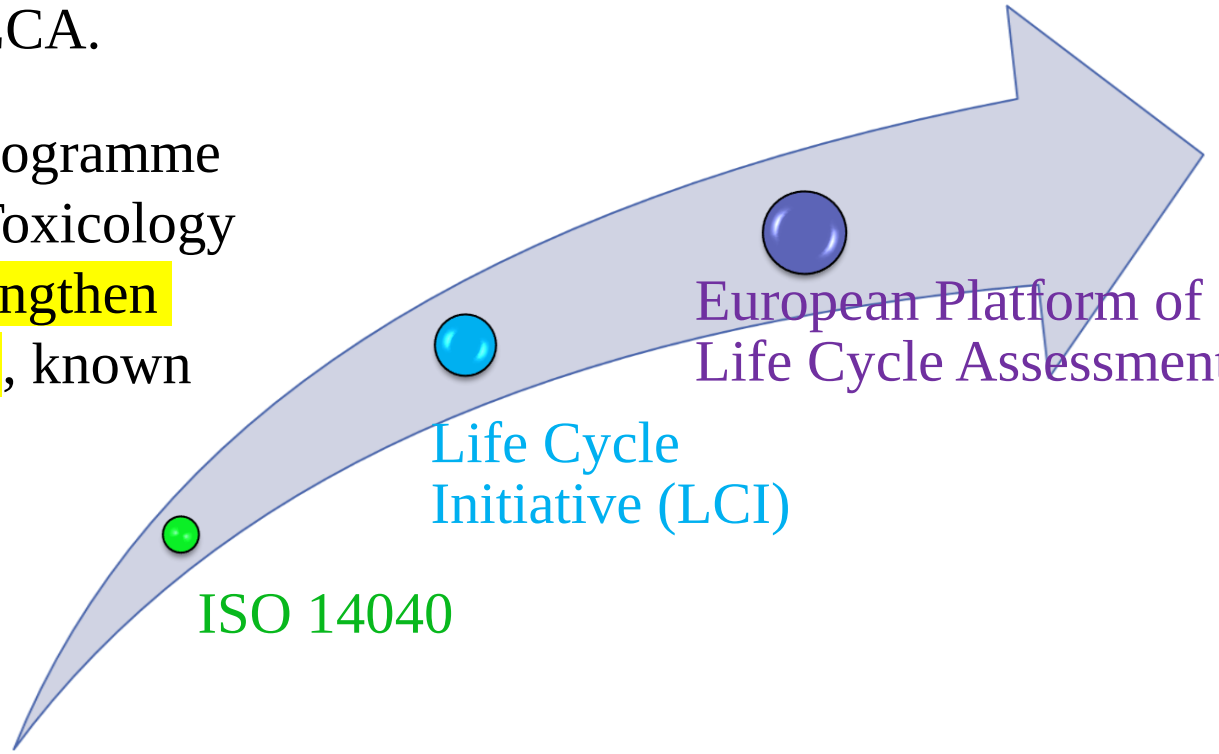
LCA Applications and Sustainability

- Explain the **main motivations** for use of **LCA by governments**, **industry**, and **citizens** and their main types of LCA applications.
- Demonstrate an understanding of the **challenges** and **opportunities** in the different types of LCA applications.
- Explain the most common interpretations of the definition of **sustainable development** from our common future.
- Account for the relevance of environmental protection to sustainability.
- Describe the type of **sustainability strategy** that LCA may support and discuss its limitations.

1. Background

Background

- To facilitate the application of LCA and life cycle thinking in society, some efforts have been made.
- In **1997**, the first version of the **ISO 14040** standard was published to harmonize the framework and principles of LCA.
- In **2001**, The United Nations Environment Programme (UNEP) and the Society for Environmental Toxicology and Chemistry (SETAC) joined forces to strengthen the dissemination and use of LCA worldwide, known as the Life Cycle Initiative (LCI).
- The European Platform of Life Cycle Assessment, launched in **2005**. Its objective was to "promote life cycle thinking in business and in policy making".



LCA Fundamentals: What are ISO14040/14044?

Hauschild, M. Z., Rosenbaum, R. K., & Olsen, S. I. (2018). Life cycle assessment (Vol. 2018). Springer International Publishing.

Application of LCA in Decision-making

- **LCA** is applied to support decision-making.
  - **Policy formulation**,
  - **Policy implementation**,
  - **Policy evaluation**.

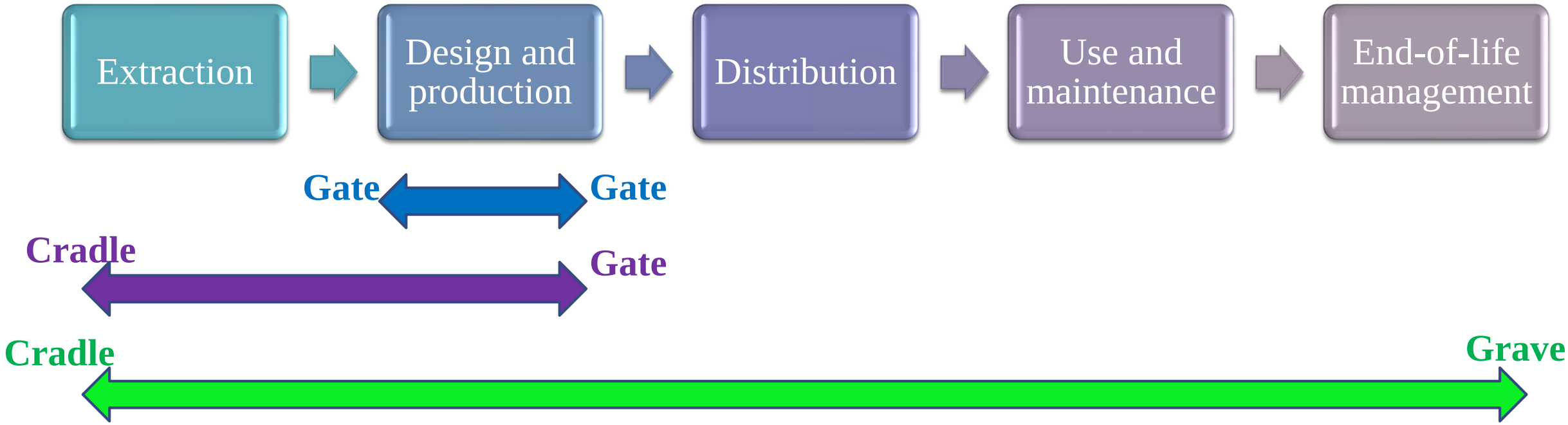
LCA applications at different stages of the policy cycle	Geographical scope
LCA as a knowledge tool in policy formulation	
Integrated product policy (IPP)	2003; EU
Strategy for the sustainable use of natural resources	2005
Sustainable production and consumption action plan (SCP)	2007; EU
LCA & policy implementation	
Eco-labelling	Various countries
Environmental product declarations (EPD)	Various countries
Waste management	France, Mexico, japan
LCA as a tool for policy evaluation	
Thematic strategy on prevention and recycling of waste & Waste framework directive	2005; EU
Waste oil directive	2000; EU

Hauschild, M. Z., Rosenbaum, R. K., & Olsen, S. I. (2018). Life cycle assessment (Vol. 2018). Springer International Publishing.

Policy Formulation

- The European Commission has promoted Integrated Product Policy (IPP) to **minimize** environmental impacts of products through various tools:

- **Environmental labelling** or green **taxation**,
- **Subsidies** or financial support to industries,
- Regulation such as the **eco-design**.



Hauschild, M. Z., Rosenbaum, R. K., & Olsen, S. I. (2018). Life cycle assessment (Vol. 2018). Springer International Publishing.

Policy Implementation and Evaluation

- Governments may use LCA as decision support for the introduction of novel technologies in the market (e.g. introduction of electric cars) or the selection of waste management systems

- In **Denmark**, LCA was used in the 1990s to guide the development of the **collection system for beverage containers** (glass and plastic bottles and aluminium cans).
- In **Switzerland**, LCA was used to justify compensation rates to municipalities in the case of waste glass packaging (Meylan et al., 2014).
- In **Sweden**, LCA was used to assess environmental impacts of introducing waste incineration tax, to encourage waste reduction and increase materials recycling (Björklund and Finnveden, 2007).
- In the **United States**, LCA was used to support management of used oil and support selection of least-polluting options (refining and reuse, distillation or combustion with energy recovery) by the state (Reed, 2012).

Hauschild, M. Z., Rosenbaum, R. K., & Olsen, S. I. (2018). Life cycle assessment (Vol. 2018). Springer International Publishing.

Class Participation 2

1. Search for **additional cases** (e.g., the use of biofuels, introduction of electric cars, or subsidies and carbon tax policy) **using LCA** as **decision support** to advice the introduction of novel technologies in the market.

2. Write down your findings in a paragraph and upload them to Canvas.

3. Engage in a class discussion to share your perspectives.

Hauschild, M. Z., Rosenbaum, R. K., & Olsen, S. I. (2018). Life cycle assessment (Vol. 2018). Springer International Publishing.

Industry Perspective

❑ The application of LCA in enterprises can be classified into **five main purposes**:

(i) Decision support in product and process development;

(ii) Marketing purposes (e.g. **eco-labelling**);

(iii) Development and selection of indicators used in monitoring of environmental performance of products or plants;

(iv) **Selection of suppliers** or subcontractors;

(v) **Strategic planning**.

Hauschild, M. Z., Rosenbaum, R. K., & Olsen, S. I. (2018). Life cycle assessment (Vol. 2018). Springer International Publishing.

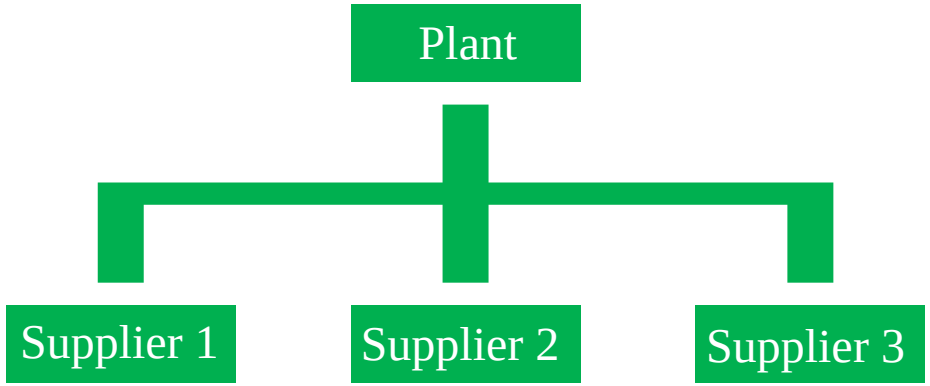
Industry Perspective

- LCA applications within industry may well serve **more than one purpose**:

For example,

- **Product development** is often combined with **marketing efforts**.
- The evaluation of **product environmental performance** can lead to decisions about **selection of suppliers** or **setting strategies**.

This product is made with at least 50% sustainable materials, using a blend of both recycled polyester and organic cotton fibers. The blend is at least 10% recycled fibers or at least 10% organic cotton fibers.



Source: Nike Sportswear Tech Fleece Men's Joggers. Nike.com

Hauschild, M. Z., Rosenbaum, R. K., & Olsen, S. I. (2018). Life cycle assessment (Vol. 2018). Springer International Publishing.

Citizen Perspective

- Customers are considering the **environmental attributes** of the **products** (e.g., recyclable) along with the **environmental practices** of **companies** (e.g., involving a recycling plan).

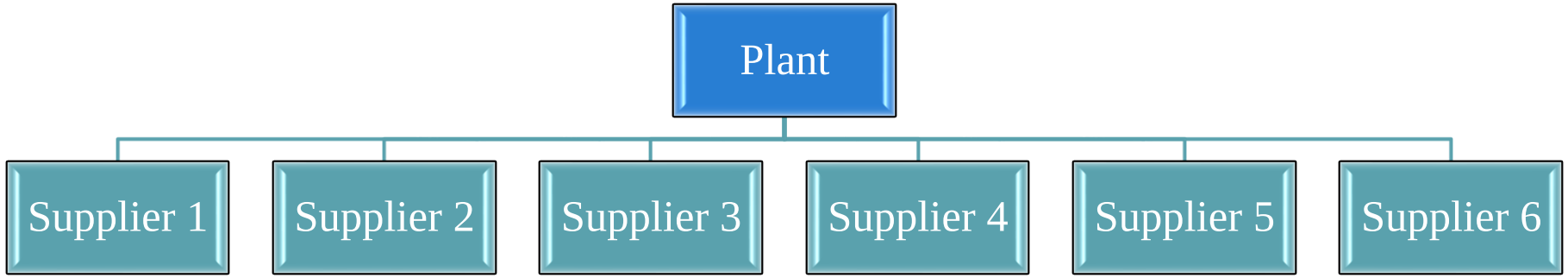
- Companies have been motivated to be a part of recycling plans to benefit from either tangible or intangible competitive advantages of such strategic decisions.

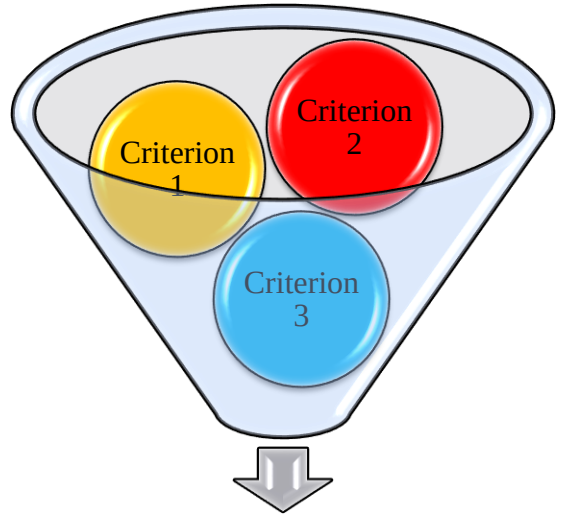
- For example,
  - The recovery of used products creates values as the **return on investments** for returned products.
  - In addition, companies can deliver an **environmentally friendly image** to the community by offering return options.

Hauschild, M. Z., Rosenbaum, R. K., & Olsen, S. I. (2018). Life cycle assessment (Vol. 2018). Springer International Publishing.

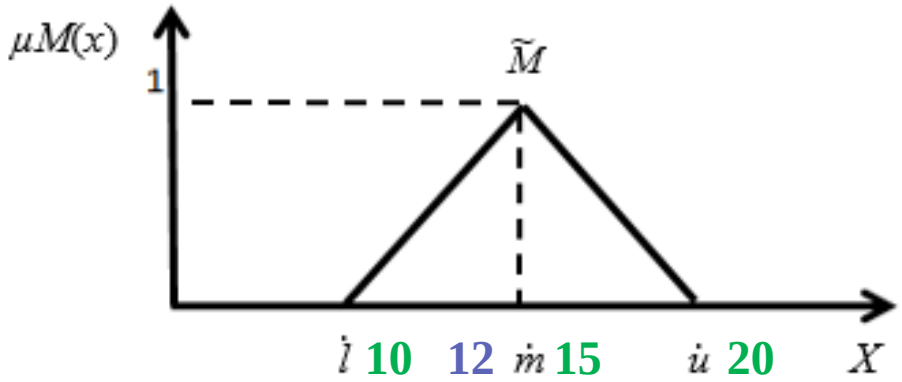
Making Sustainable Strategic Decisions

- **Selecting suppliers** with a focus on **environmental factors** involves evaluating potential suppliers based on their **environmental practices** and sustainability **initiatives**.





Supplier Selection Based on Fuzzy Logic



A triangular fuzzy number $\tilde{M}$.

If $\tilde{M}$ is assumed as a TFN by three components such as $\tilde{M}=(\dot{l},\dot{m},\dot{u})$, the associated membership function is shown by Eq. (1).

$$\mu M(x)=\begin{cases} 0, & x<\dot{l}, \\ \dfrac{x-\dot{l}}{\dot{m}-\dot{l}}, & \dot{l}\le x\le \dot{m}, \\ \dfrac{\dot{u}-x}{\dot{u}-\dot{m}}, & \dot{m}\le x\le \dot{u}, \\ 0, & x>\dot{u}, \end{cases} \qquad (1)$$

$$\frac{12\text{-}10}{15\text{-}10} = 40\%$$

Class Participation 3

1. Download the **Excel file** from Canvas (Resources) and employ TOPSIS method for supplier selection with environmental consideration.

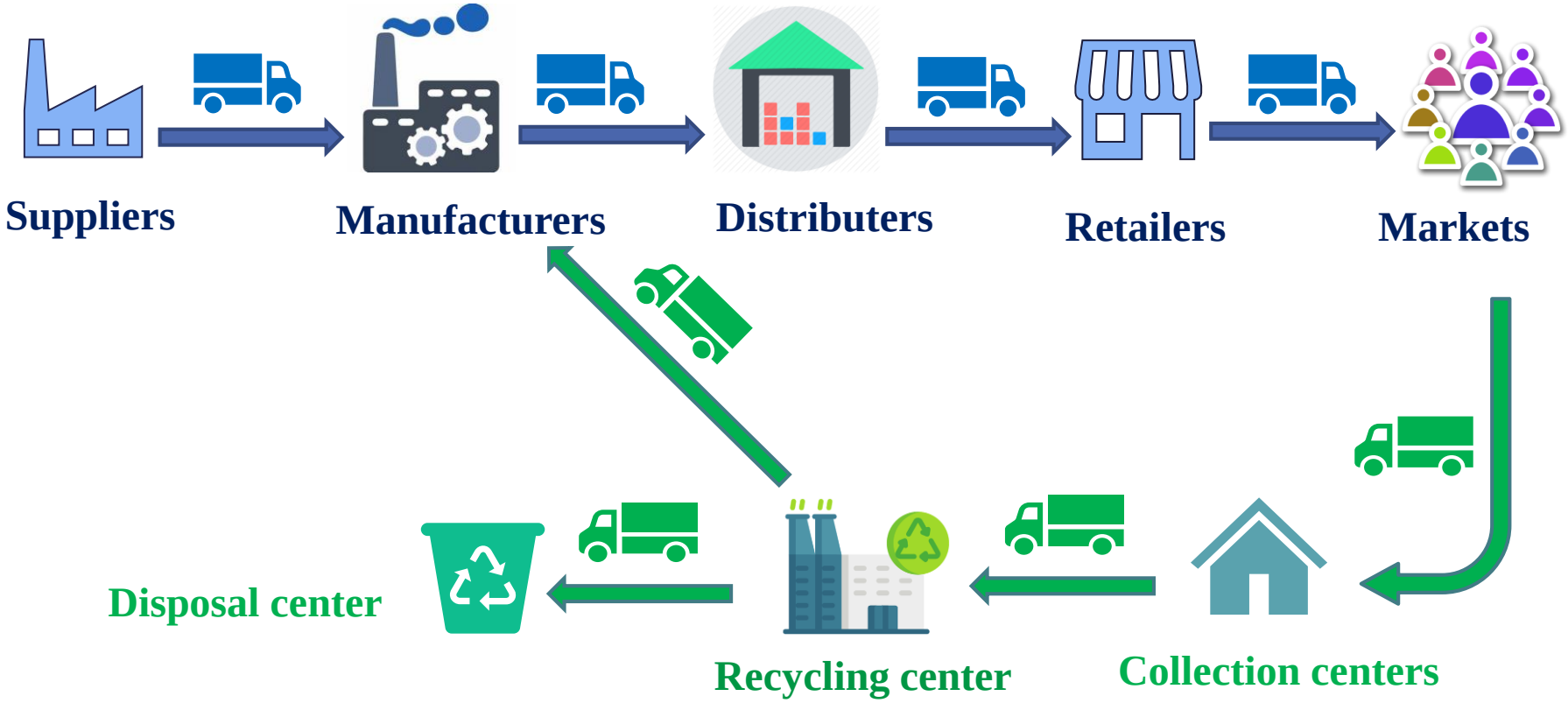
2. Identify **environmental criteria** from literature.

3. Rank Suppliers using linguistics scales and upload your Excel file to Canvas.

From the Environmental Concerns to a Life Cycle Perspective

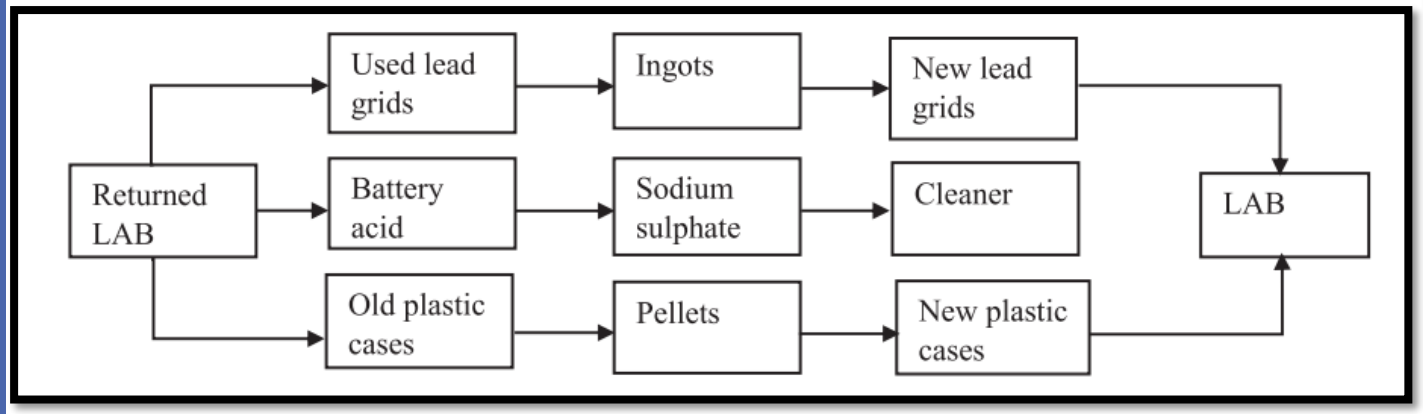
❑ **Closed-loop Supply Chain (CLSC):** **Integration of Forward and Reverse Logistics Network**

- End-of-life
- End-of-use

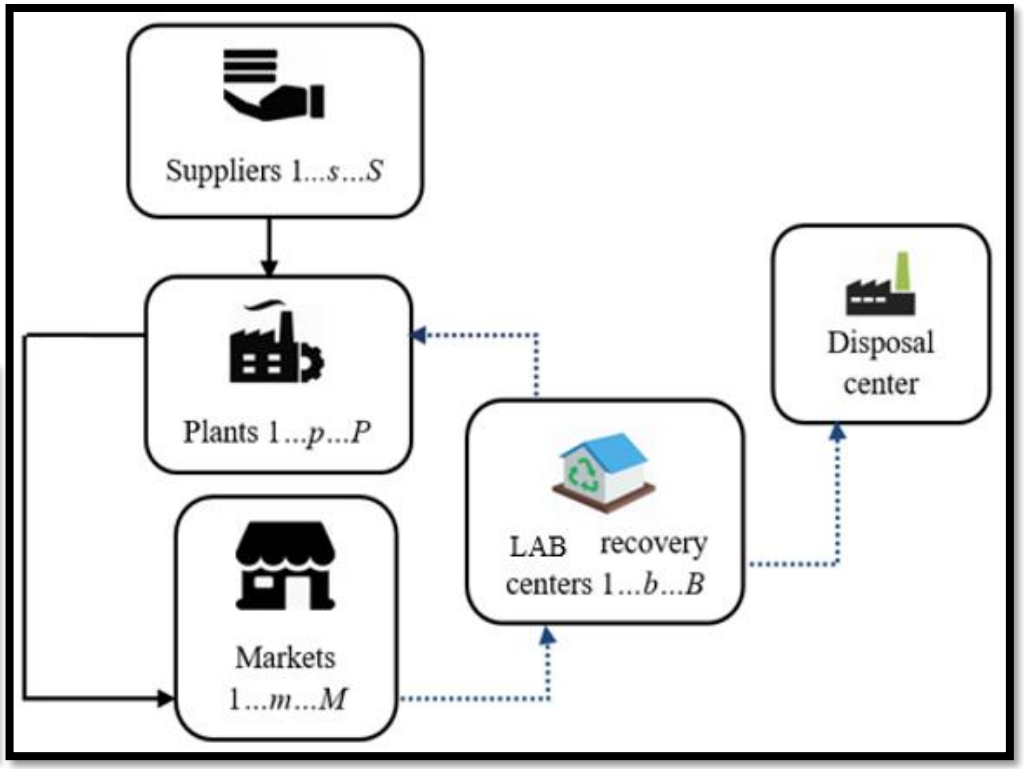


From the Environmental Concerns to a Life Cycle Perspective

- The issue of **environmental sustainability** is of great interest today.
- Companies are encouraged to adopt cleaner production systems and technologies.
- The emerging interest encourages a sustainable management of suppliers, producers and distributers.



The recycling method of lead acid battery (CBA stewardship program, 2016)

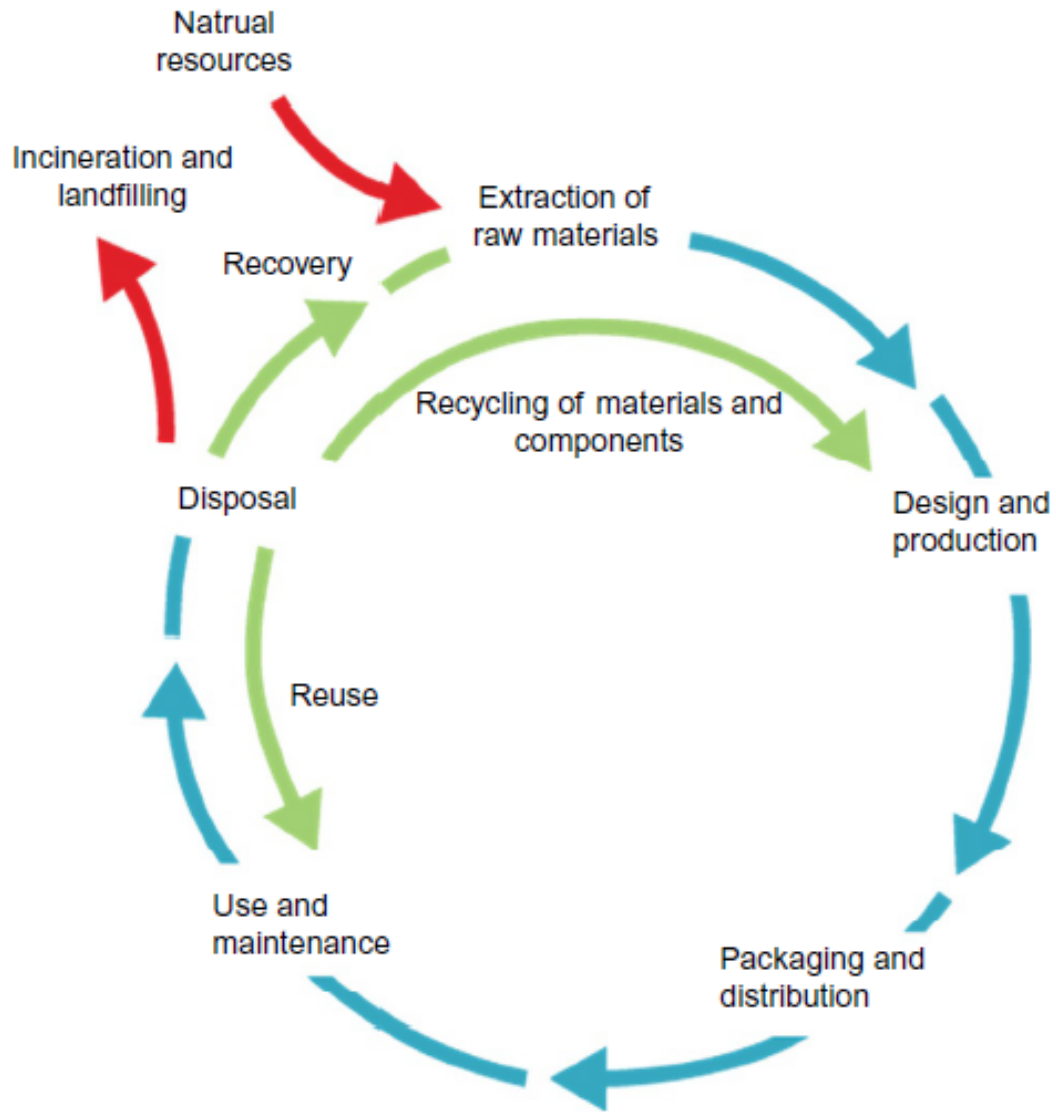


Tosarkani, B. M., & Amin, S. H. (2019). An environmental optimization model to configure a hybrid forward and reverse supply chain network under uncertainty. *Computers & Chemical Engineering*, *121*, 540-555.

Hauschild, M. Z., Rosenbaum, R. K., & Olsen, S. I. (2018). Life cycle assessment (Vol. 2018). Springer International Publishing.

A Typical Product Life Cycle

- A product's life cycle can begin with the **extraction of raw materials** from natural resources in the ground.
- **Materials** and **energy** are then part of production, packaging, distribution, and eventually recycling, reuse, recovery, or final disposal.
- In each life cycle stage there is the **potential** to **reduce resource consumption** and improve the product's performance.



Source: Life Cycle Thinking

Hauschild, M. Z., Rosenbaum, R. K., & Olsen, S. I. (2018). Life cycle assessment (Vol. 2018). Springer International Publishing.

The Main Goals of Life Cycle Thinking

To reduce a product's resource use

To maximize economic benefits

To minimize emissions

To improve social development

Hauschild, M. Z., Rosenbaum, R. K., & Olsen, S. I. (2018). Life cycle assessment (Vol. 2018). Springer International Publishing.

Sustainable Development

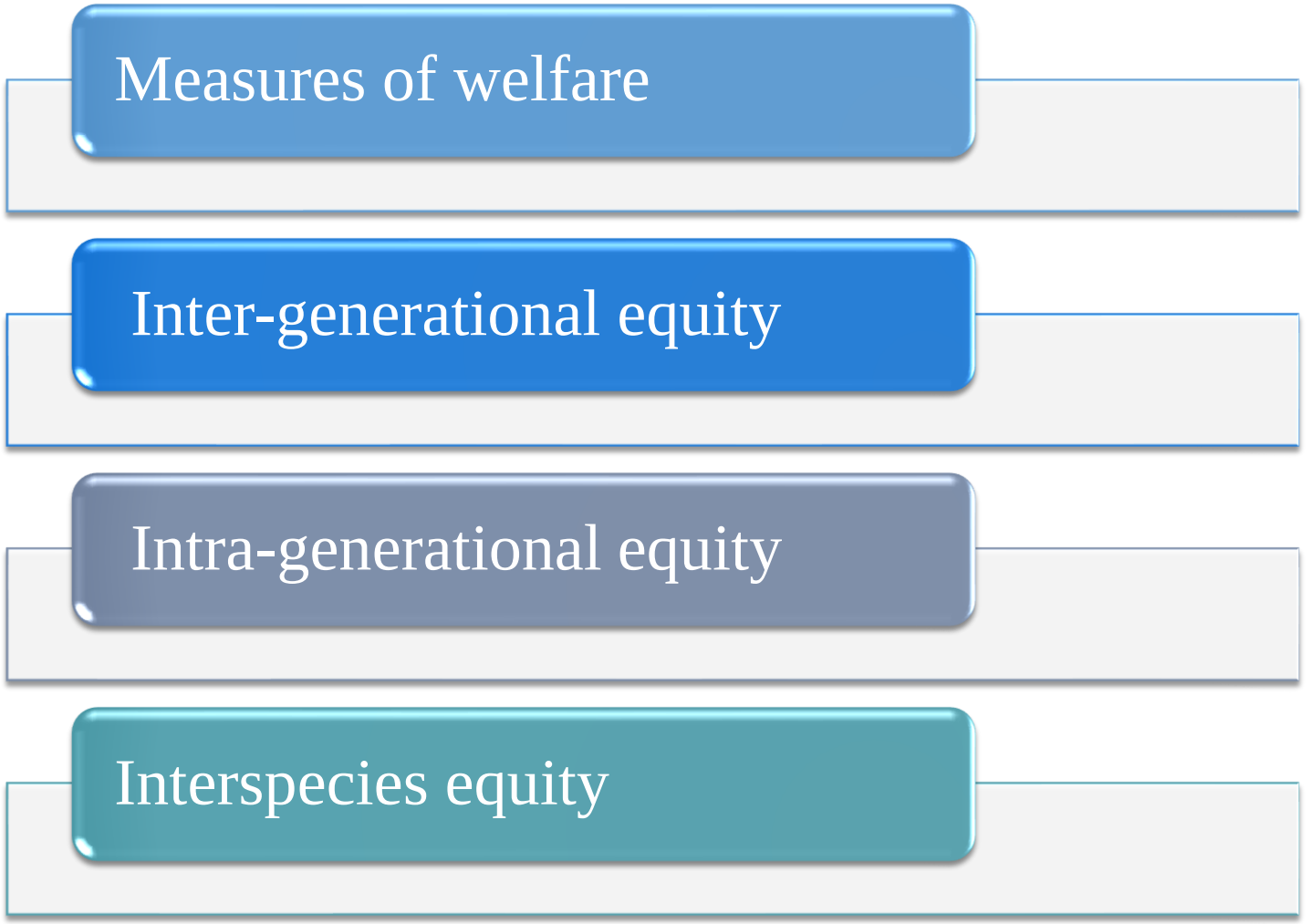
- Sustainable development: "… development that meets the needs of the present without compromising the ability of **future generations** to meet their own needs" (Brundtland and Khalid, 1987; United Nations General Assembly, 1987, p. 43).

- A natural question may therefore be;

  - How does LCA and sustainable development relate?
  - To what extent can LCA be used as a methodology for informing decisions towards sustainability?

Brundtland, G. H., & Khalid, M. (1987). *Our common future*. Oxford University Press, Oxford, GB.

Dimensions of sustainable development



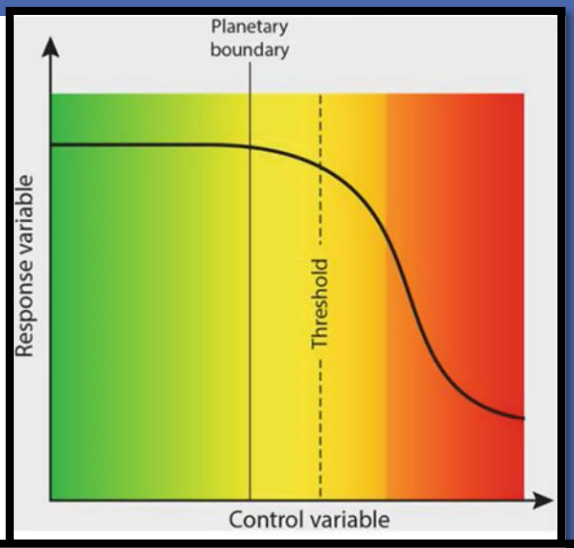
Hauschild, M. Z., Rosenbaum, R. K., & Olsen, S. I. (2018). Life cycle assessment (Vol. 2018). Springer International Publishing.

Dimensions of Sustainability

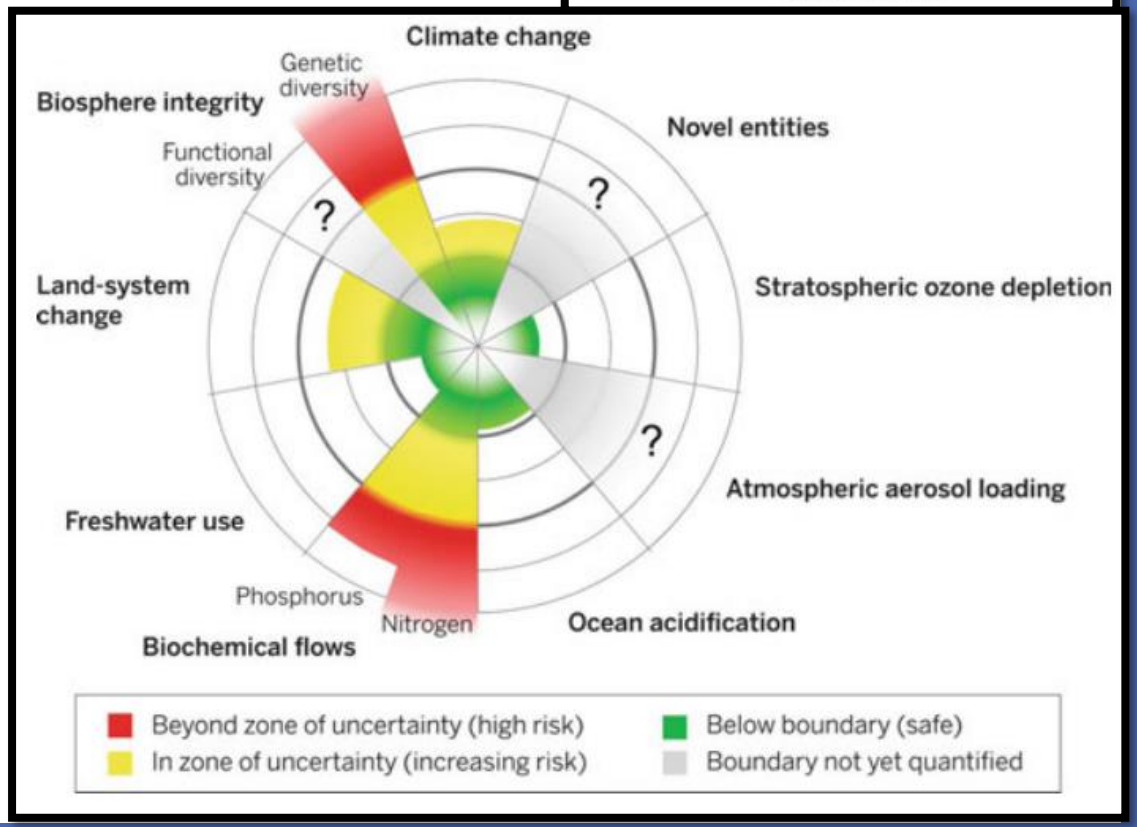
- The **first dimension** is related to measures of **welfare** including several concepts, such as "**need**", "**utility**", "**happiness**" and "**aspiration**".
- The **second dimension** relates to the concern for **inter-generational equity**, i.e. a concern for the equity in the welfare between **this** and **future generations**.
- The **third dimension** relates to **intra-generational equity**. We consider the extent to which the measures of welfare are equally distributed within a generation both on:
  - A **macro-scale** (i.e. the equality among developed and developing nations).
  - A **micro-scale** (i.e. the equality within a given nation, region or local community).
- The **fourth dimension** relates to **interspecies equity**, relating to whether it is only the welfare of humans is a goal, or other living organisms should also be considered.

Sustainability and the Environmental Concern

- **Protecting the environment** is necessary to give future generations the same possibilities for achieving the levels of welfare that current generations are experiencing.
- Carrying capacities of ecosystems must not be exceeded to maintain its functionality.



- The proposed **nine planetary boundaries** (two of them subdivided for specific pressures).
- Some of them are. **beyond** the **zone of uncertainty**



Hauschild, M. Z., Rosenbaum, R. K., & Olsen, S. I. (2018). Life cycle assessment (Vol. 2018). Springer International Publishing.

Life Cycle Sustainability Assessment

- To expand LCA into life cycle sustainability assessment (LCSA) for considering social and economic aspects, in addition to environmental aspect.

LCSA = LCA + **LCC** + **SLCA**

- LCC: life cycle costing
- SLCA: social life cycle assessment

"*If you really think that the environment is less important than the economy, try holding your breath while you count your money*" (McPherson 2009).

Hauschild, M. Z., Rosenbaum, R. K., & Olsen, S. I. (2018). Life cycle assessment (Vol. 2018). Springer International Publishing.