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- Sustainability……

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- ……doesn't mean a green strategy.
- Sustainability is much bigger…
- …… because it takes into account every dimension of the business environment:
- **social, economic, and natural**

2

- Until the 1980s, business leaders used the word sustainability to mean a company's ability to increase its earnings steadily.

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- The term became widely used in its present sense in 1987, after it appeared in a UN report by Norway's former prime minister Gro Harlem Brundtland,...

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- who defined sustainability as...

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- ... "meeting the needs of the present without compromising the ability of future generations to meet their own needs."

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<https://www.mckinsey.com/business-functions/strategy-and-corporate-finance/our-insights/when-sustainability-means-more-than-green>

<https://www.mckinsey.com/business-functions/sustainability/our-insights/the-challenge-of-climate-change>

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## Engineering Without Conscience?



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## Engineering Without Conscience?

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## Engineering Without Conscience?

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- What are the current issues driving ...
  - Engineers
  - Managers
  - Entrepreneurs
  - Researchers
  - Governments
- ... to think about sustainability?

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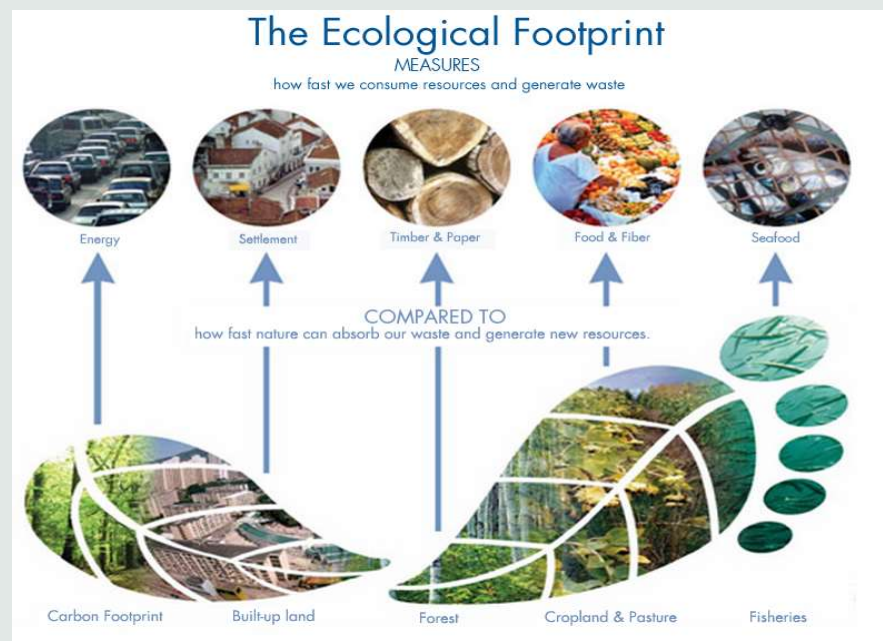
**One Earth** (or Earth Planet) is the amount of resources that the Earth regenerates in one year.

Resources coming from fisheries, forests and soil that are primarily used for food, power and transportation.

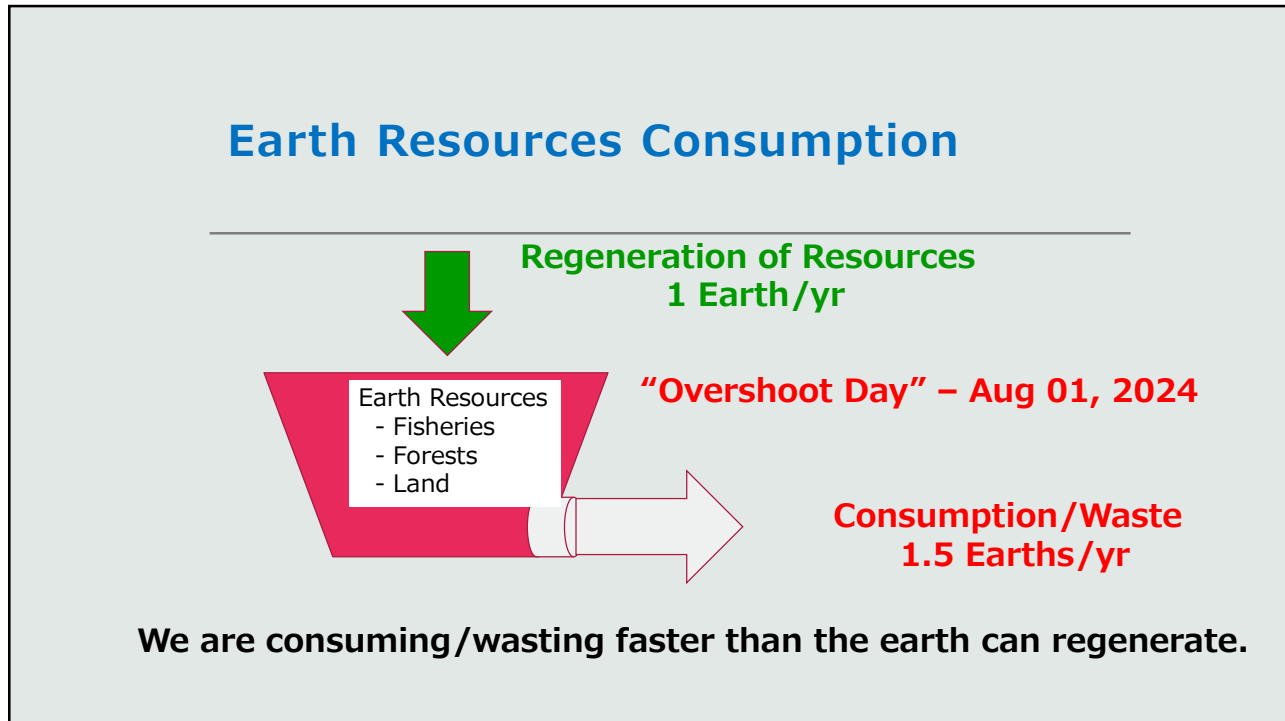
**Today, humanity is running at a rate of 1.5 Earths/yr!!**

Earth Planet = "the amount of biologically productive land and sea area necessary to supply the resources a human population consumes, and to assimilate associated waste."

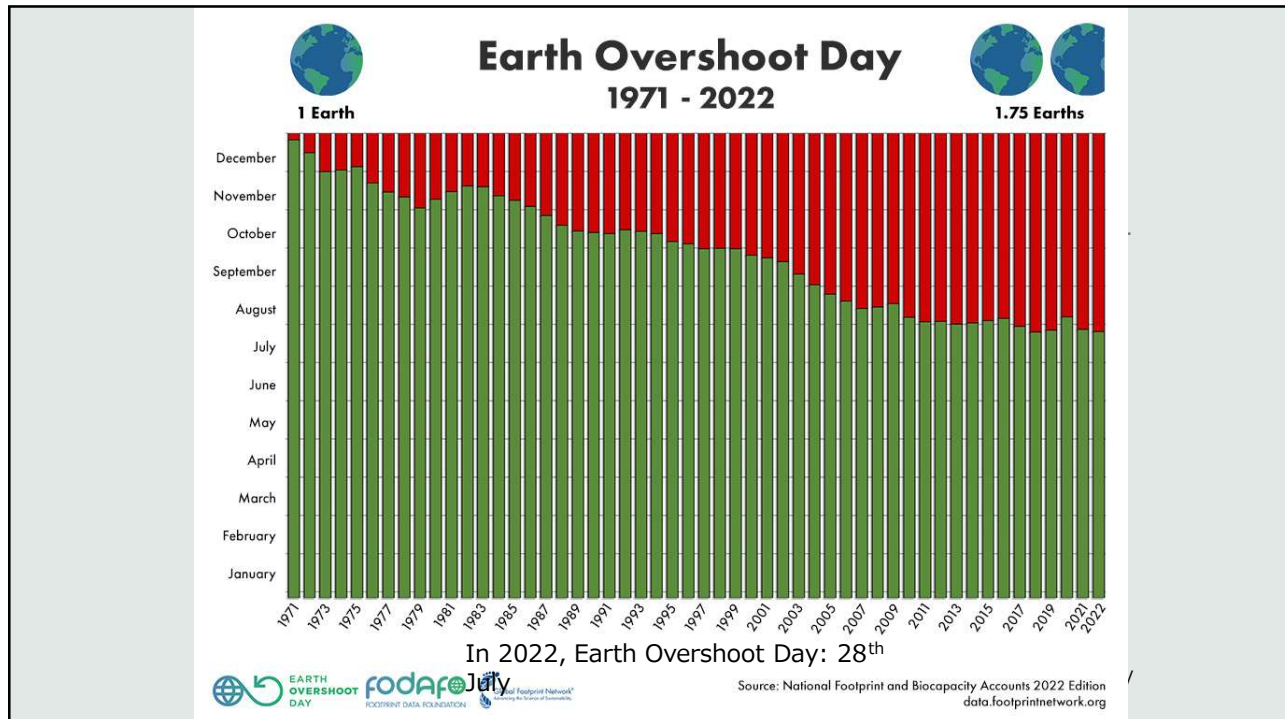
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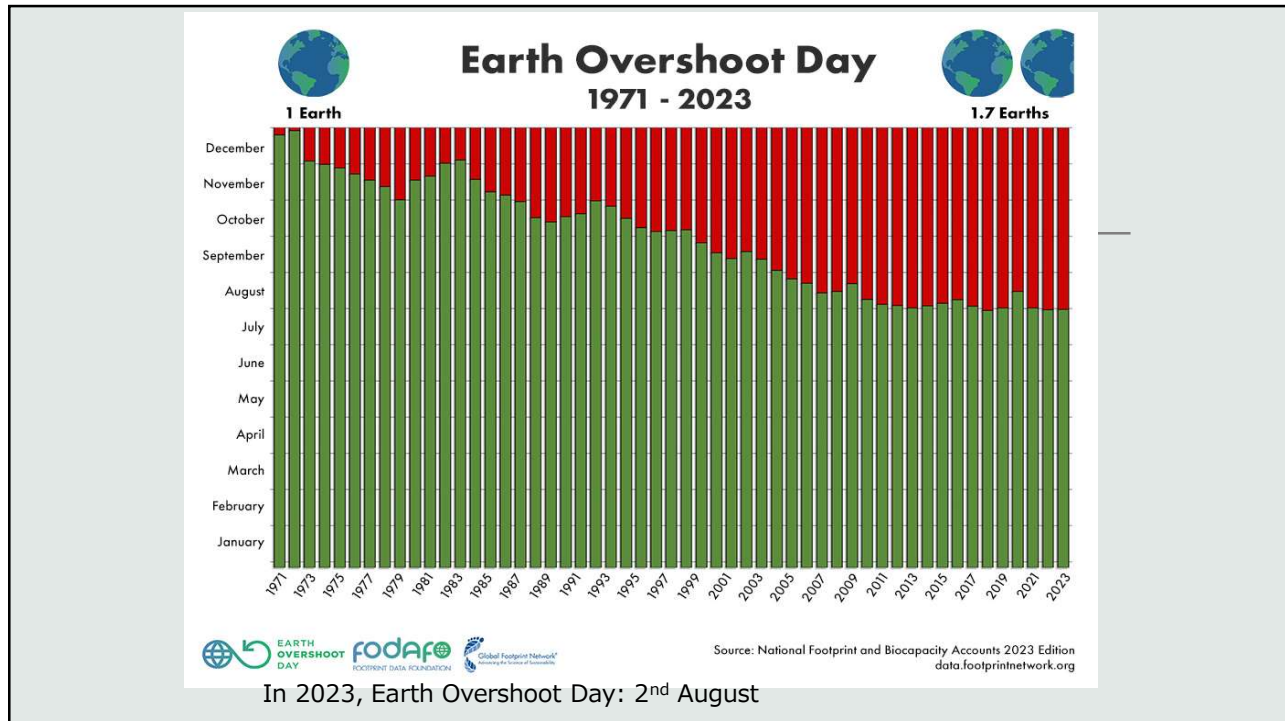
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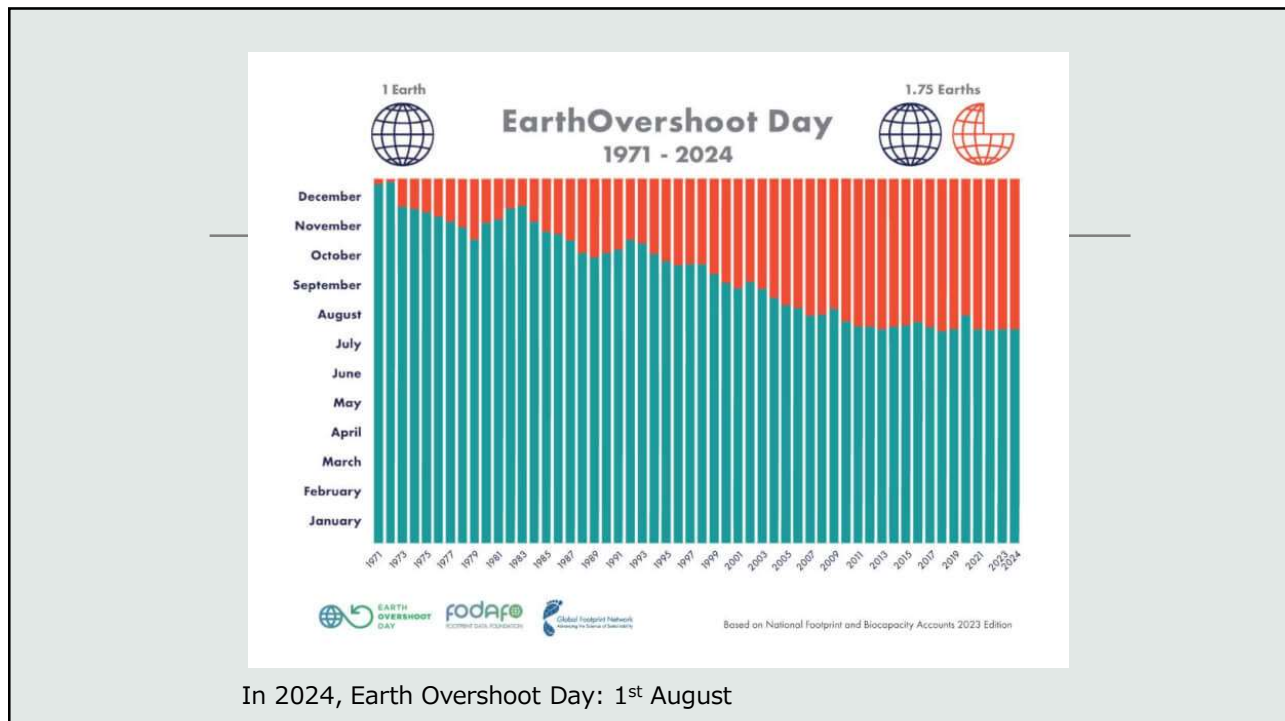
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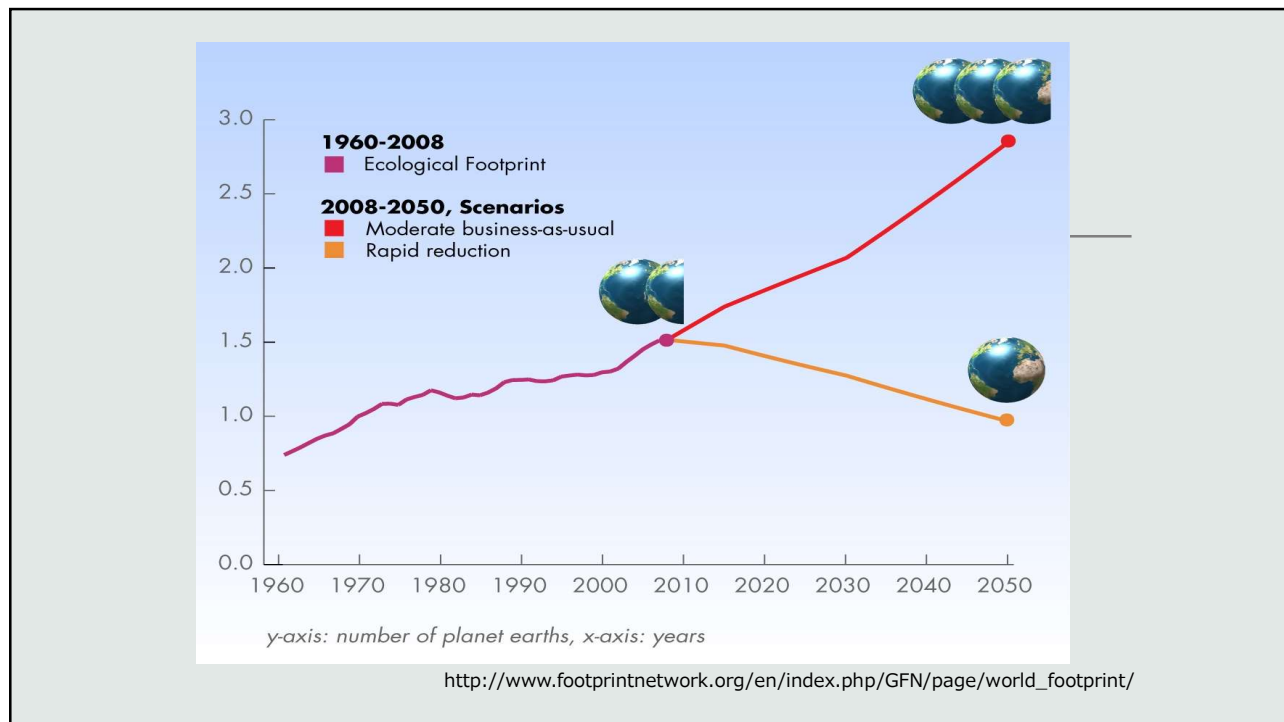
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## Elements of Sustainability

**Economic** – example: develop a process to use industrial waste rather than have to pay to get rid of it

**Social** – develop products that don't disproportionately affect one population

**Environmental** – example: develop processes and products that minimize pollution

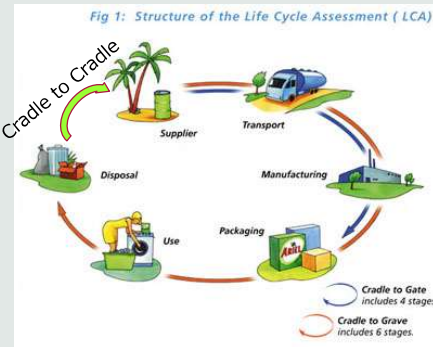
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## How do we judge if a product or service is sustainable?

### Life Cycle Assessment (LCA)

Audit the total impact of the product's or service's

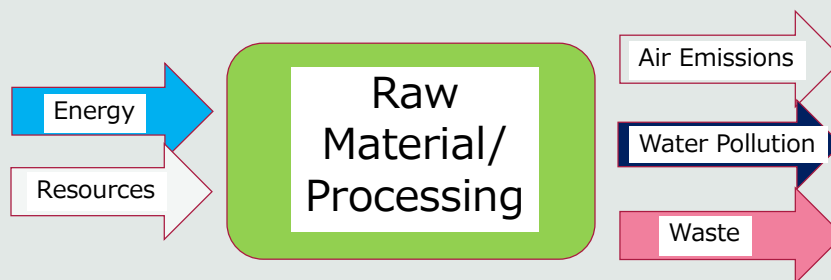
1. *Materials*
2. *Manufacturing*
3. *Packaging*
4. *Use*
5. *Disposal*
6. *Transportation*



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## Life Cycle Assessment

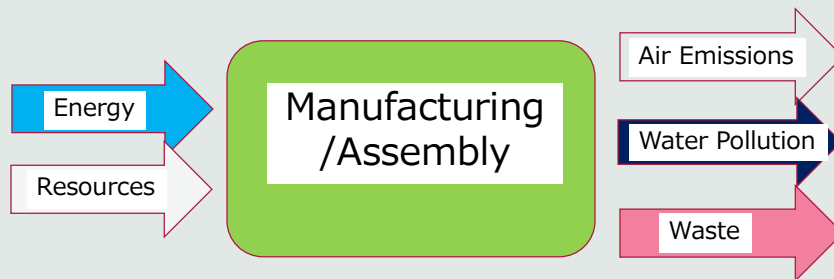
- Audit in Terms of Energy and Resources



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## Life Cycle Assessment

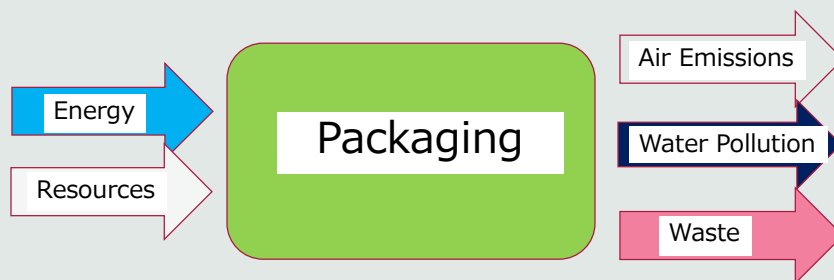
- Audit in Terms of Energy and Resources



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## Life Cycle Assessment

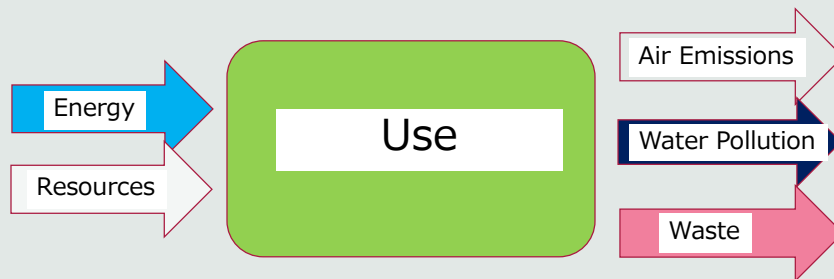
- Audit in Terms of Energy and Resources



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## Life Cycle Assessment

- Audit in Terms of Energy and Resources



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## Life Cycle Assessment

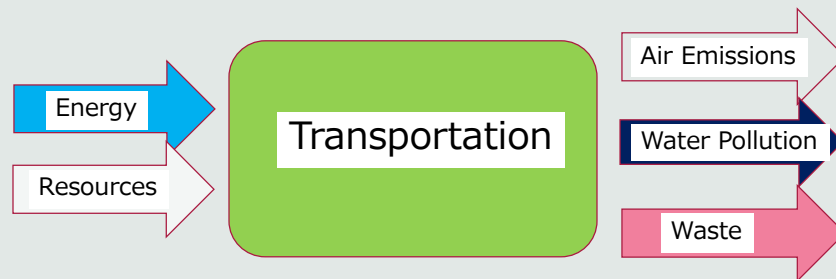
- Audit in Terms of Energy and Resources



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## Life Cycle Assessment

- Audit in Terms of Energy and Resources



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## Circular Economy

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- Instead of a usual approach of 'take-make-throw', an extractive industrial model...
- ..... circular economy aims to redefine growth focusing on society wide benefits entailing from...
- ..... gradual decoupling of economic activities from finite resources

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## Circular Economy

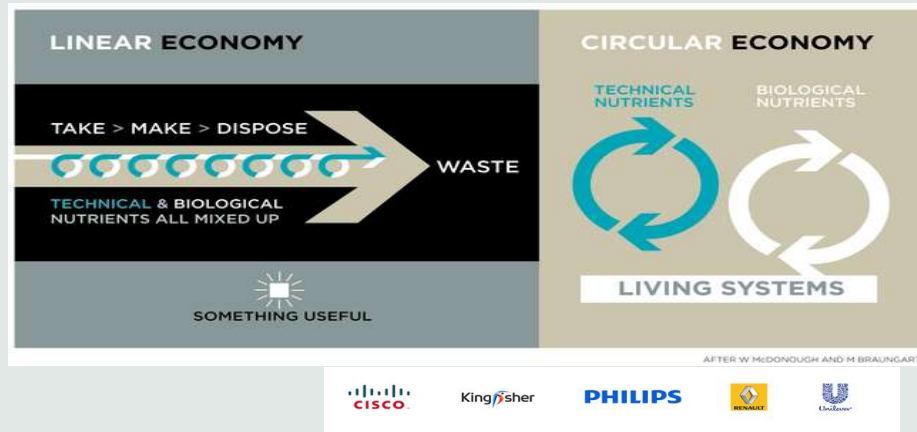
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- Instead of a usual approach of 'take-make-throw', an extractive industrial model...
- ..... circular economy aims to redefine growth focusing on society wide benefits entailing from...
- ..... gradual decoupling of economic activities from finite resources

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## Circular Economy

a new vision for a sustainable future



Ellen MacArthur Foundation – Rethink the future (2010)

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# CIRCULAR ECONOMY

<https://www.ellenmacarthurfoundation.org/>

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In a circular economy, growth is decoupled from the consumption of scarce resources.

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Products and materials are kept within productive use for as long as possible…

……and when they reach end of use,

……they are effectively cycled (or looped) back into the system.

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Arriving at true circularity means…

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…… rethinking and transforming full value chains to create a system in which waste is designed out entirely and

……the goal is net positivity (adding instead of extracting resources) through restorative models.

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'Circular economy' is...

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..... the concept of a truly sustainable economy that works without waste, saves resources and is in synergy with the biosphere.

Rather than seeing emissions, by-products or damaged and unwanted goods as "waste",

..... in the circular economy they become raw material, nutrients for a new production cycle'.

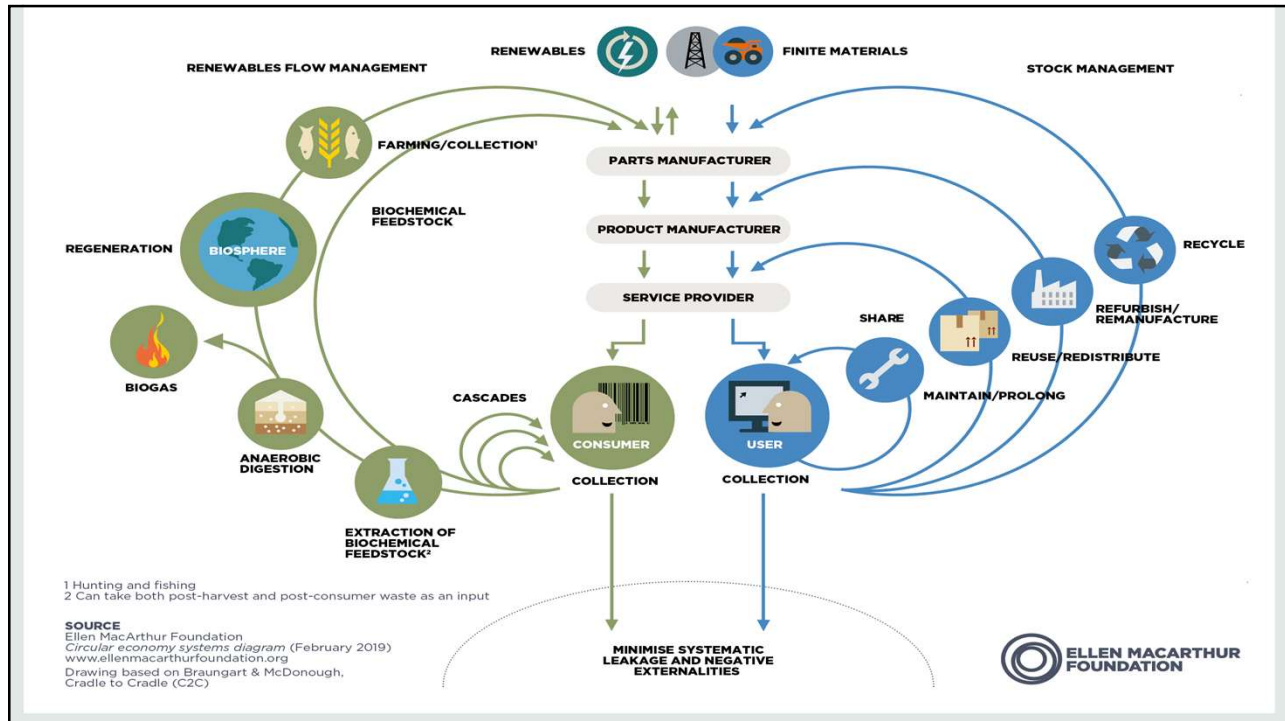
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The circular and continuous flow of both technical and biological materials through "value circles" is illustrated by "

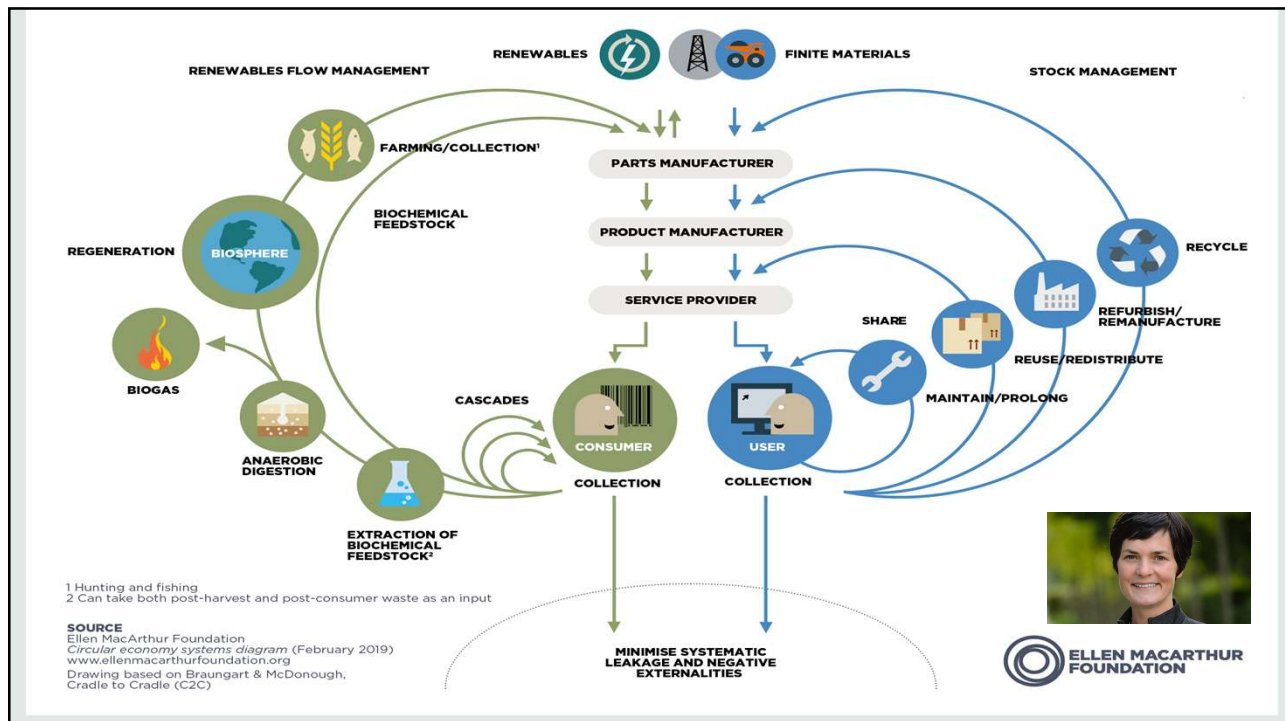
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..... The Circular Economy Systems Diagram"

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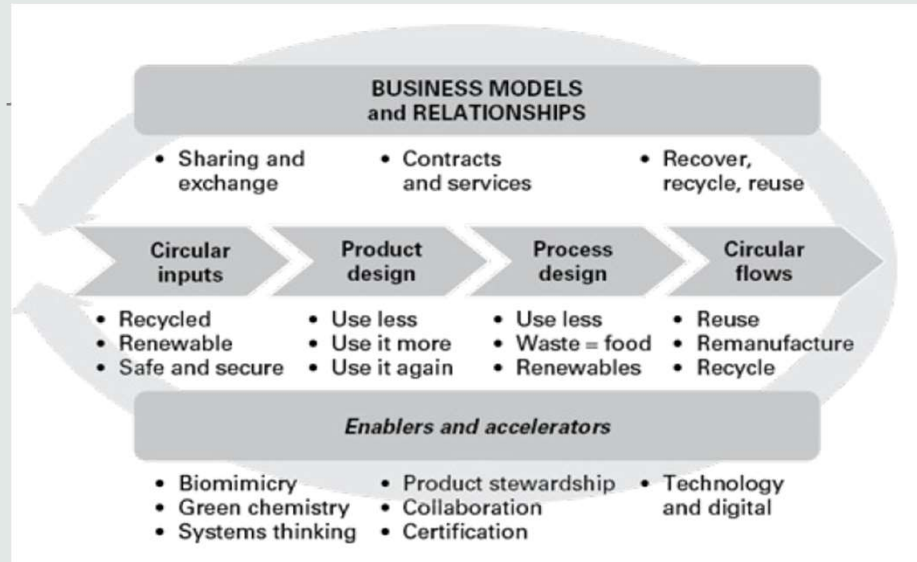


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## C.E. FRAMEWORK



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## C.E. FRAMEWORK

**Product Stewardship** is an environmental management strategy that means ..... whoever designs, produces, sells, or uses a product,

..... takes responsibility for minimizing the product's environmental impact throughout all stages of the products' life cycle, including end of life management.

**Systems thinking** is a holistic approach to analysis.....

..... that focuses on the way that a system's constituent parts interrelate and how systems work overtime and within the context of larger systems.

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## Circular Inputs

This means designing the product to use sustainable resources in its bill of materials.

These should be safe, non-toxic, renewable and preferably recycled.

Specifying potential substitute materials could reduce the risk of future supply shortages, improving security of supply."

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## Product Design

Good design should aim for durability, enabling the product to last longer for its first and subsequent 'lives' (or use cycles) and so that it can be used again.

Design should enable and encourage circular flows to keep the product, parts and materials circulating at the highest value, for the longest period.

Design should simplify disassembly at the end of each use cycle to enable easy access to future resources. "

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## Process Design

Manufacturing process should include planning circular flows to safeguard 'nutrients' for future use.

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Processes should minimize resource use, both

For materials and

For process inputs including energy, water and other process aids

..... that become embedded resources in the product.

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## Circular Flows

How best can you set up circular, or 'output recovery' flows?

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These include:

**Reuse options**, where the product is resold or shared;

**Remanufacturing** so that the product matches 'as new' performance for a second life;

**Recycling** to enable the materials or components to be used in another product.

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