22/09/2022

AllCan
Introduction à l'économie circulaire

CentraleSupélec

université PARIS-SACLAY

INTERVENANTS

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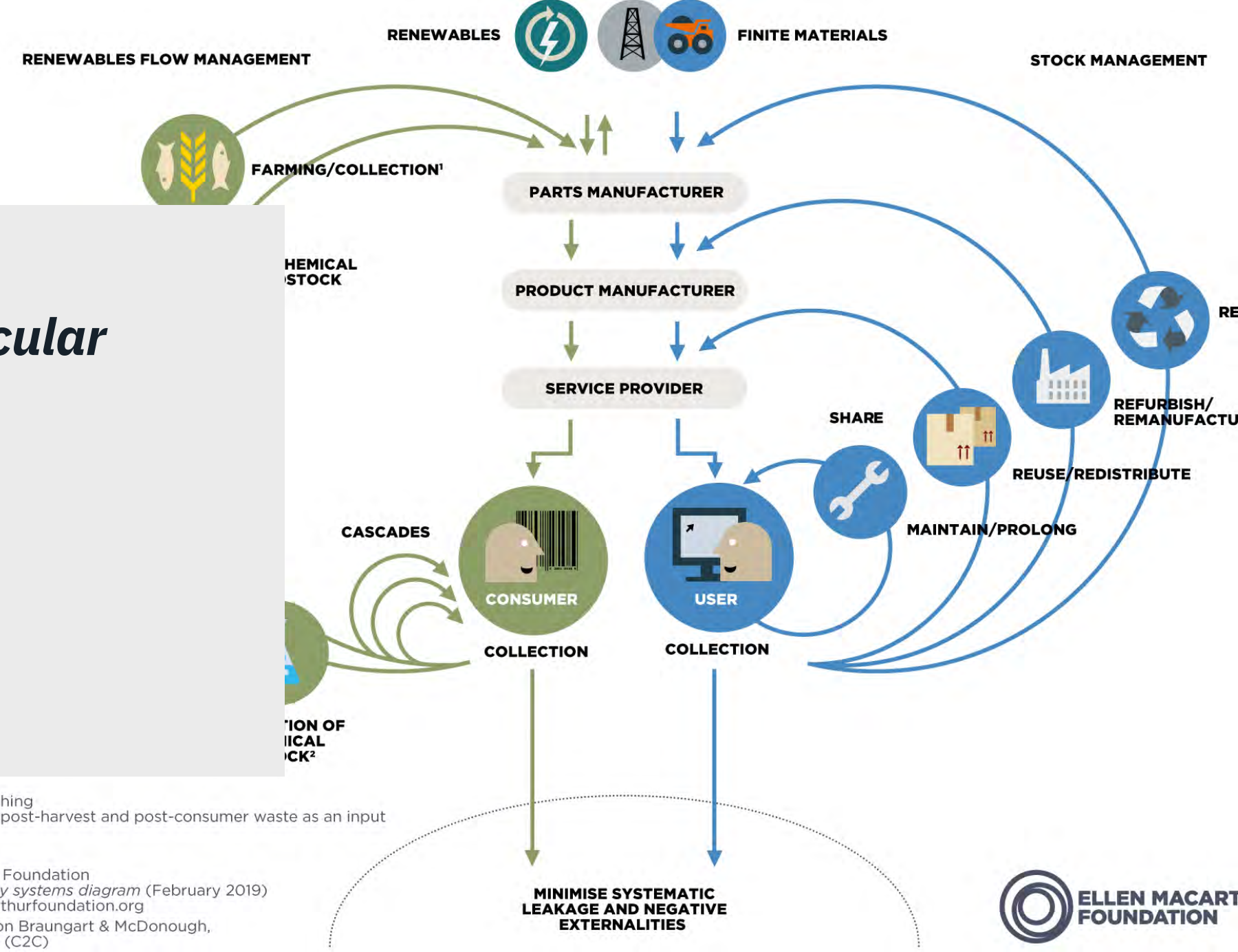
01

Course
Introduction to Circular Economy



ıg and fishing
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acArthur Foundation
r *economy systems diagram* (February 2019)
lenmacarthurfoundation.org
g based on Braungart & McDonough,
to Cradle (C2C)

A

Sustainability challenges

Sustainable development

A DEFINITION

Three pillars: Economic, Social, Environmental

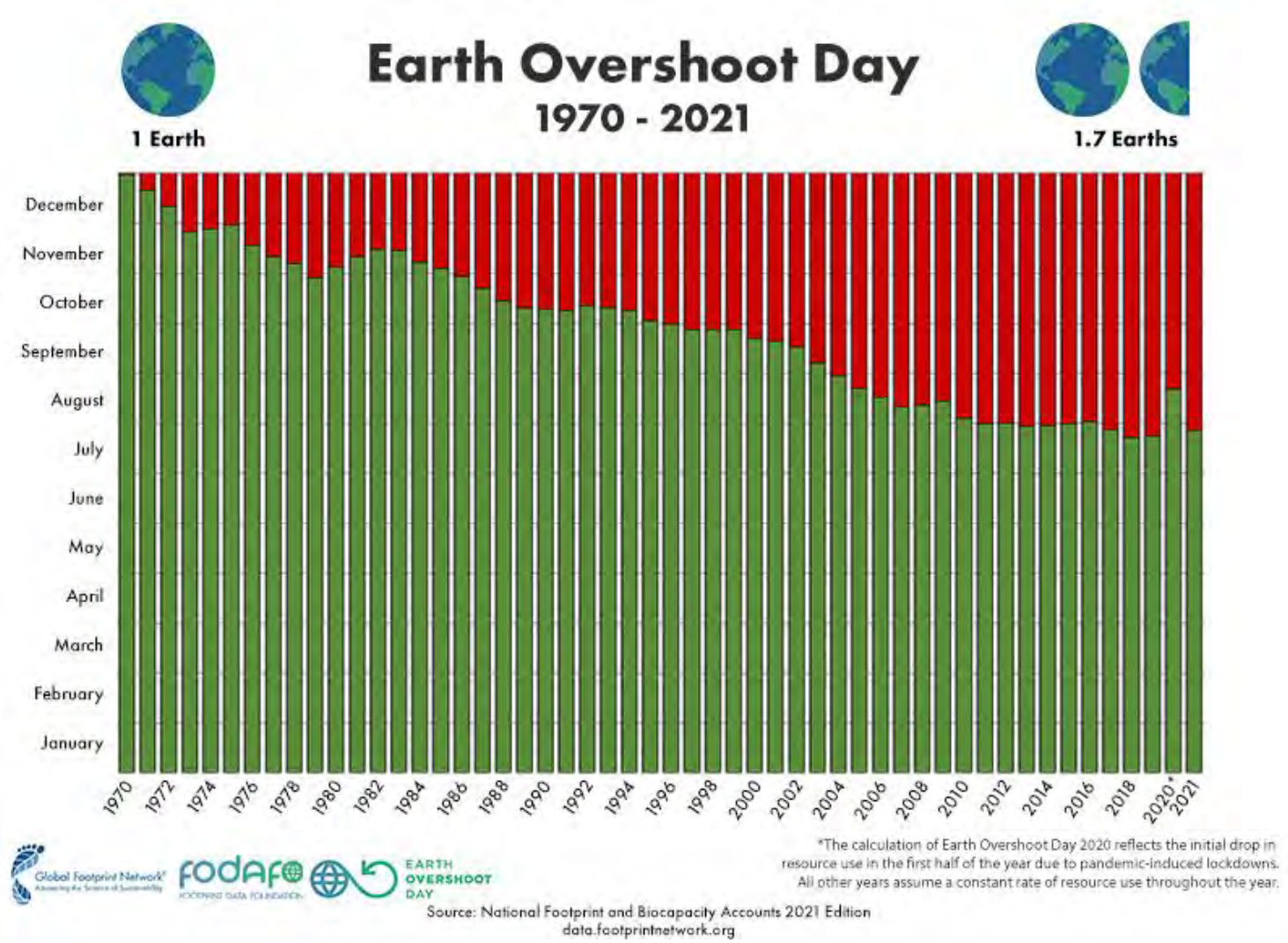
A definition: *“a development that meets the needs of the present without compromising the ability of future generations to meet their own needs .”* [Brundtland commission, 1987]

EARTH OVERSHOOT DAY

JULY 29, 2021

By July 29, 2021, we will have used more from nature than our planet can renew in the whole year.

We use more ecological resources and services than nature can regenerate through overfishing, overharvesting forests, and emitting more carbon dioxide into the atmosphere than forests can sequester.



EARTH OVERSHOOT DAY

JULY 29, 2019

Country Overshoot Days 2022

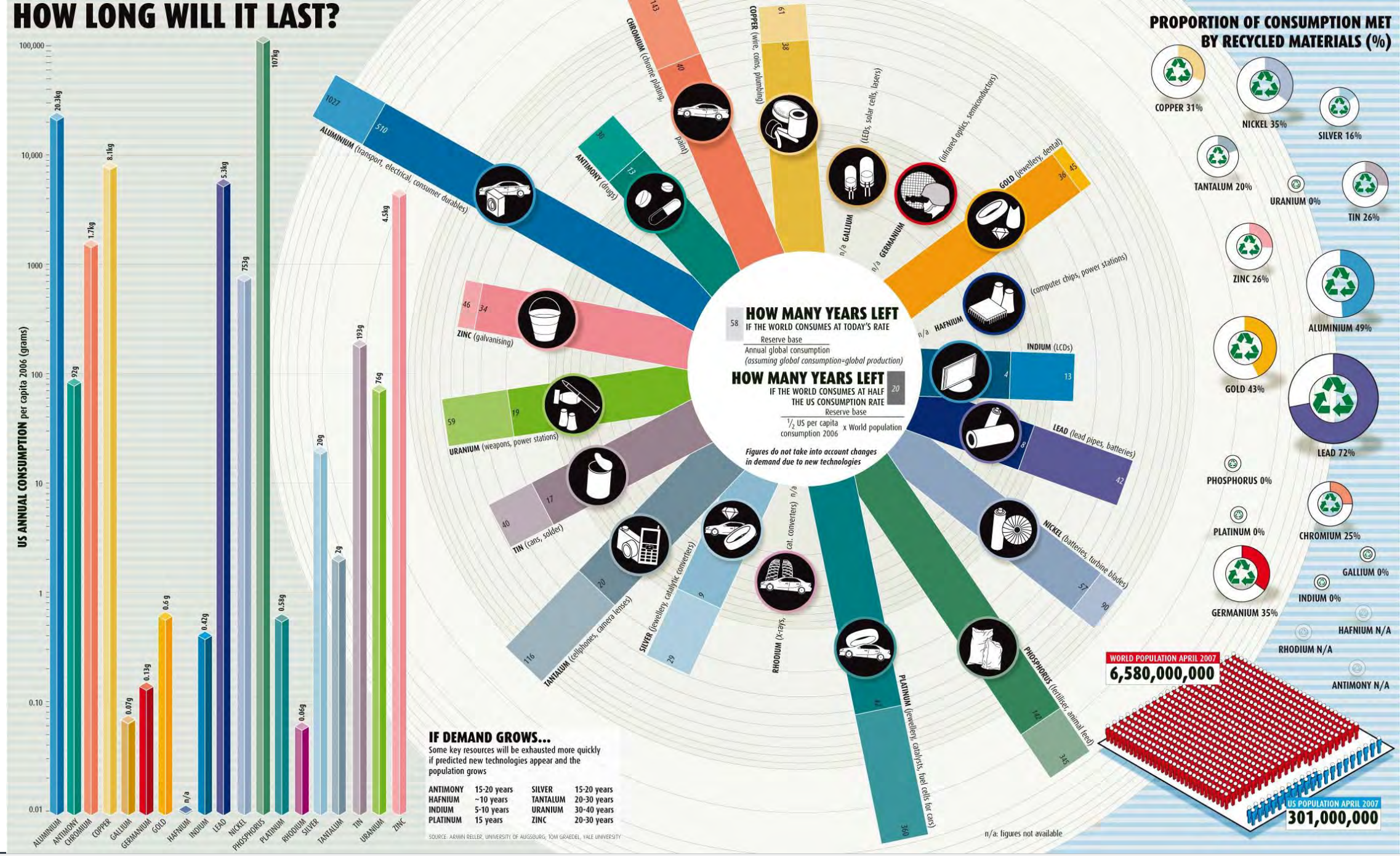
When would Earth Overshoot Day land if the world's population lived like...

For a full list of countries, visit overshootday.org/country-overshoot-days

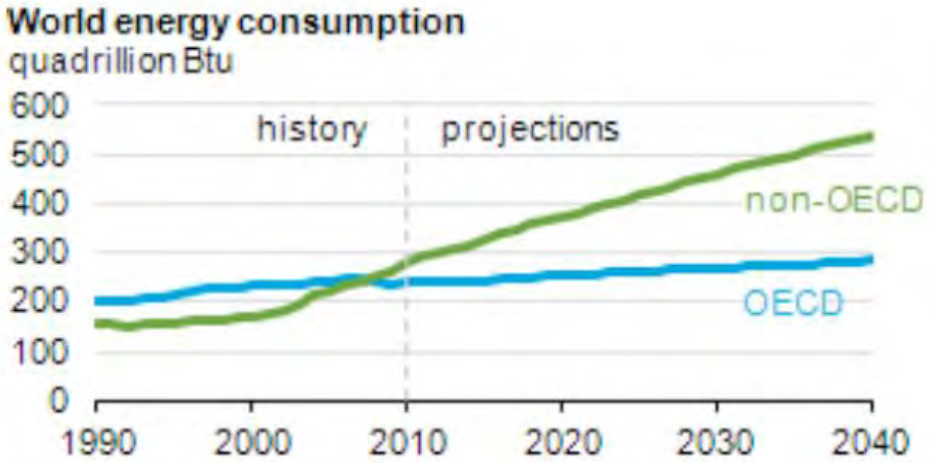
Source: National Footprint and Biocapacity Accounts, 2022 Edition
data.footprintnetwork.org

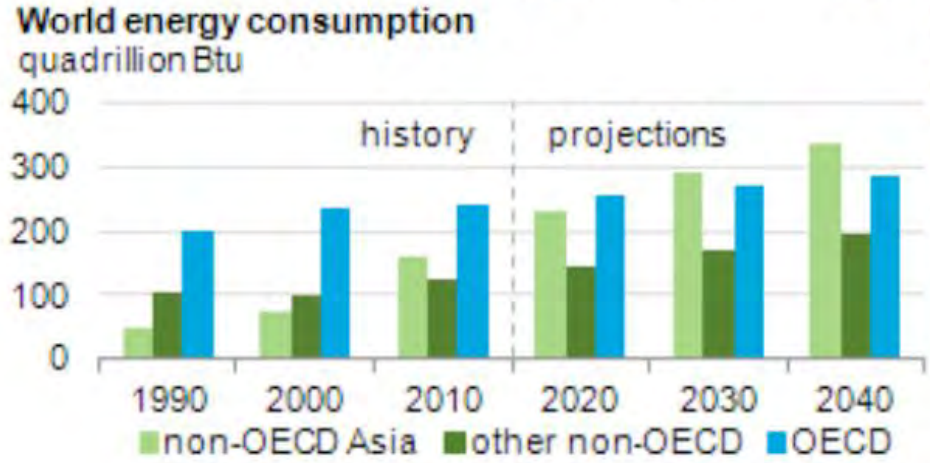
EARTH OVERSHOOT DAY

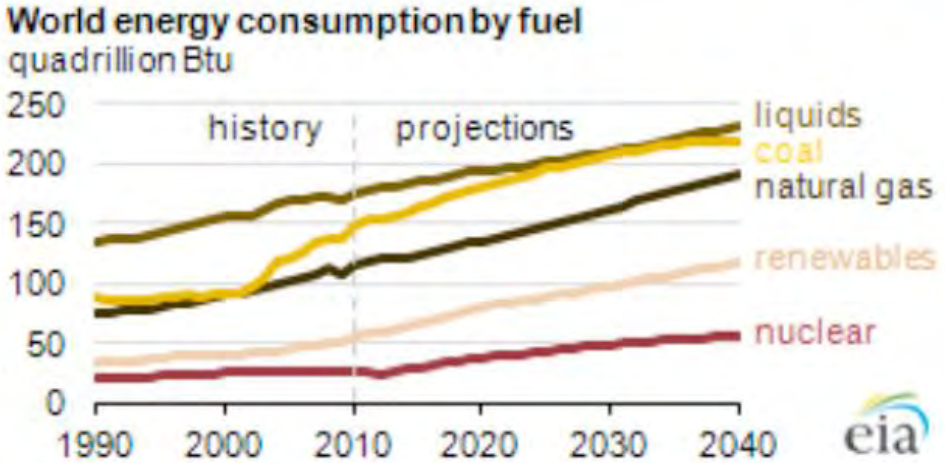
Global Footprint Network
Advancing the Science of Sustainability


HOW LONG WILL IT LAST?
US ANNUAL CONSUMPTION per capita 2006 (grams)
100,000
10,000
1000
100
10
1
0.10
0.01
20.3kg
92g
1.7kg
8.1kg
0.07g
0.13g
0.6 g
n/a
0.42g
5.3kg
753g
107kg
0.58g
0.06g
20g
29
193g
76g
4.5kg
ALUMINIUM
ANTIMONY
CHROMIUM
COPPER
GALLIUM
GERMANIUM
GOLD
HAFNIUM
INDIUM
LEAD
NICKEL
PHOSPHORUS
PLATINUM
RHODIUM
SILVER
TANTALUM
TIN
URANIUM
ZINC
ALUMINIUM (transport, electrical, consumer durables)
1027
510
ANTIMONY (drugs)
30
13
CHROMIUM (chrome plating, paint)
143
40
COPPER (wire, cans, plumbing)
61
38
GALLIUM (LEDs, solar cells, lasers)
n/a
GERMANIUM (infrared optics, semiconductors)
n/a
GOLD (jewellery, dental)
36
45
HAFNIUM (computer chips, power stations)
n/a
INDIUM (LCDs)
4
13
LEAD (lead pipes, batteries)
8
42
NICKEL (batteries, turbine blades)
52
90
PHOSPHORUS (fertiliser, animal feed)
142
345
PLATINUM (jewellery, catalysts, fuel cells for cars)
42
360
RHODIUM (x-rays, cat. converters)
n/a
SILVER (jewellery, catalytic converters)
9
29
TANTALUM (cellphones, camera lenses)
20
116
TIN (cans, solder)
17
40
URANIUM (weapons, power stations)
19
59
ZINC (galvanising)
34
46
HOW MANY YEARS LEFT
IF THE WORLD CONSUMES AT TODAY'S RATE
58
Reserve base
Annual global consumption
(assuming global consumption=global production)
HOW MANY YEARS LEFT
IF THE WORLD CONSUMES AT HALF THE US CONSUMPTION RATE
20
Reserve base
½ US per capita consumption 2006 x World population
Figures do not take into account changes in demand due to new technologies
IF DEMAND GROWS...
Some key resources will be exhausted more quickly if predicted new technologies appear and the population grows
ANTIMONY 15-20 years
HAFNIUM ~10 years
INDIUM 5-10 years
PLATINUM 15 years
SILVER 15-20 years
TANTALUM 20-30 years
URANIUM 30-40 years
ZINC 20-30 years
SOURCE: ARMIN RELLER, UNIVERSITY OF AUGSBURG; TOM GRAEDEL, YALE UNIVERSITY
PROPORTION OF CONSUMPTION MET BY RECYCLED MATERIALS (%)
COPPER 31%
NICKEL 35%
SILVER 16%
TANTALUM 20%
URANIUM 0%
TIN 26%
ZINC 26%
ALUMINIUM 49%
GOLD 43%
LEAD 72%
PHOSPHORUS 0%
PLATINUM 0%
CHROMIUM 25%
GALLIUM 0%
GERMANIUM 35%
INDIUM 0%
HAFNIUM N/A
RHODIUM N/A
ANTIMONY N/A
WORLD POPULATION APRIL 2007
6,580,000,000
US POPULATION APRIL 2007
301,000,000
n/a: figures not available

World energy forecast







Sustainable Development Goals

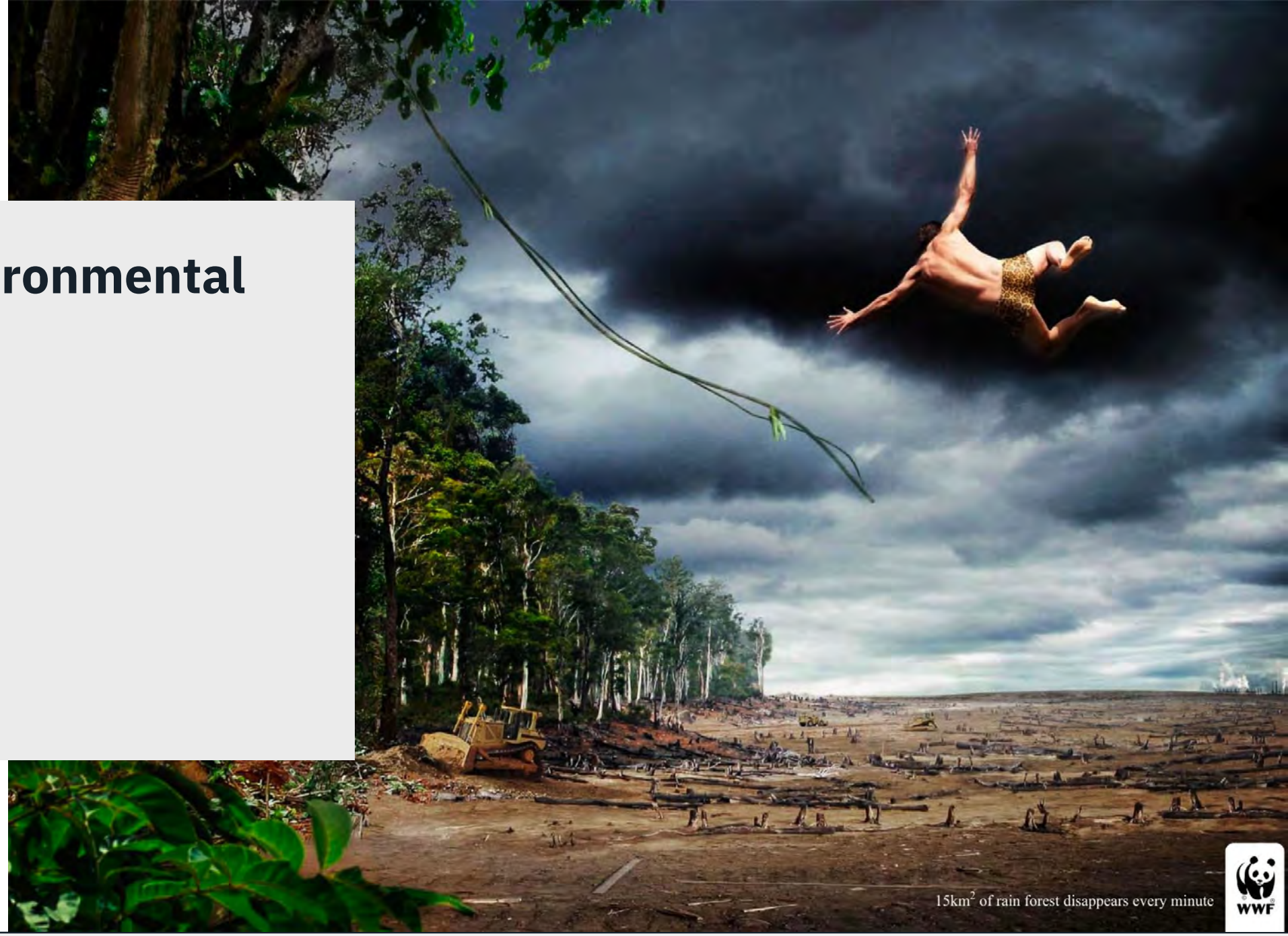
THIS IS OUR FUTURE

https://sustainabledevelopment.un.org/?menu=1300

The 2030 Agenda for Sustainable Development, adopted by all United Nations Member States in 2015, provides a shared blueprint for peace and prosperity for people and the planet, now and into the future. At its heart are the 17 Sustainable Development Goals (SDGs), which are an urgent call for action by all countries - developed and developing - in a global partnership. They recognize that ending poverty and other deprivations must go hand-in-hand with strategies that improve health and education, reduce inequality, and spur economic growth – all while tackling climate change and working to preserve our oceans and forests.

B.

What is an environmental impact?

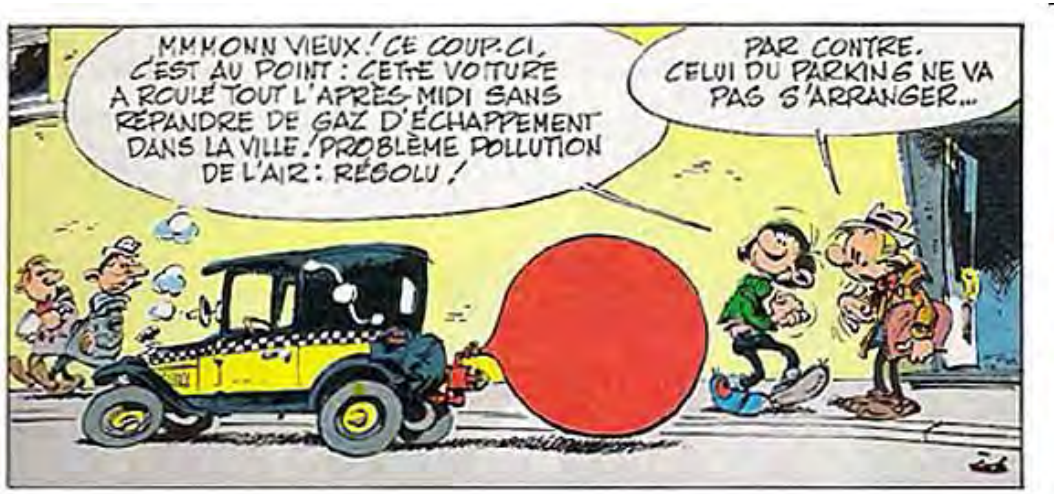


The main environmental concerns

ENVIRONMENTAL PROTECTION IS NOT LIMITED TO CO2 EMISSIONS RESTRICTION!

7 main environmental impact categories

- Raw materials
- Hazardous substances
- Energy
- Air pollution
- Water pollution
- Soils pollution
- Wastes



Main environmental mechanisms associated to those categories

Climate change

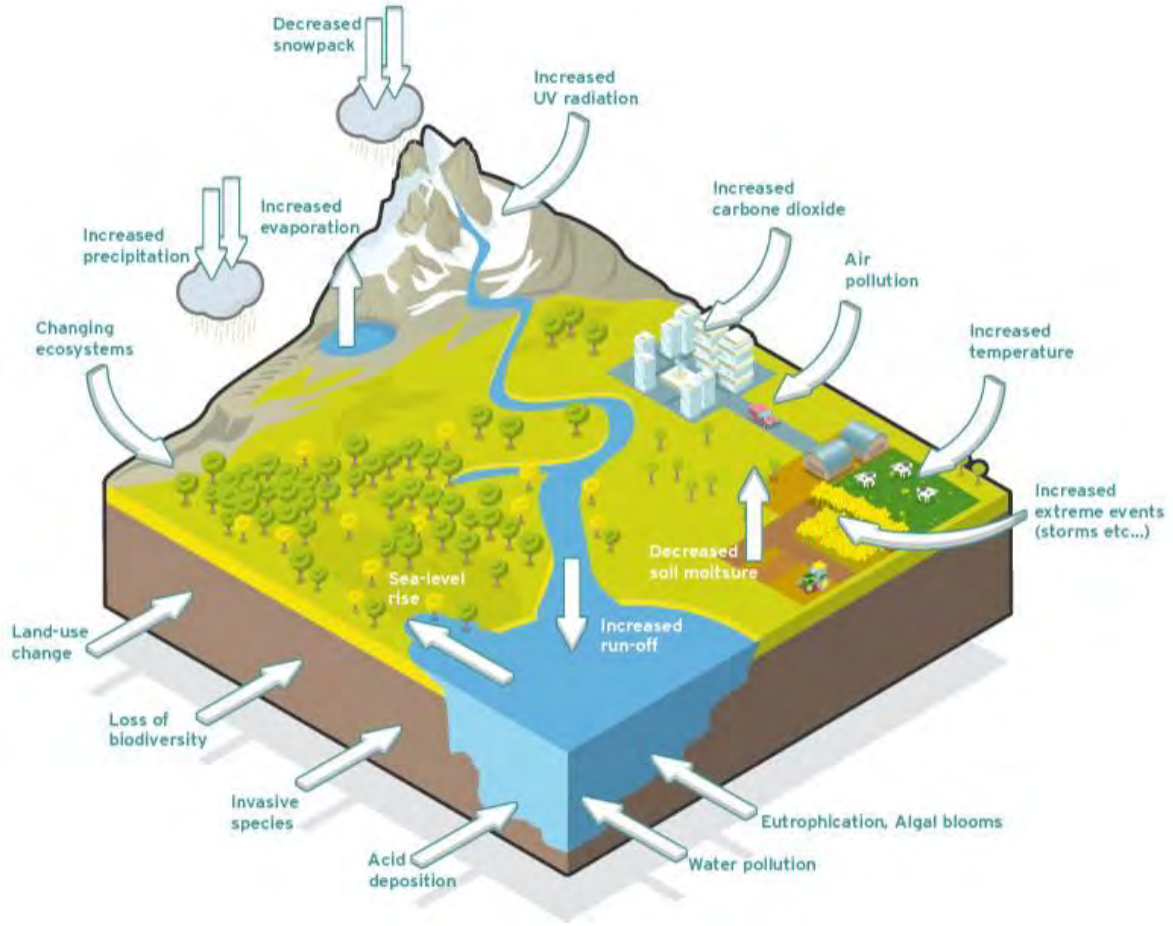
Impacts on

- Human health
- Ecosystems health

Cause

- Greenhouse gases

The radiative forcing of each gas is taken into account.



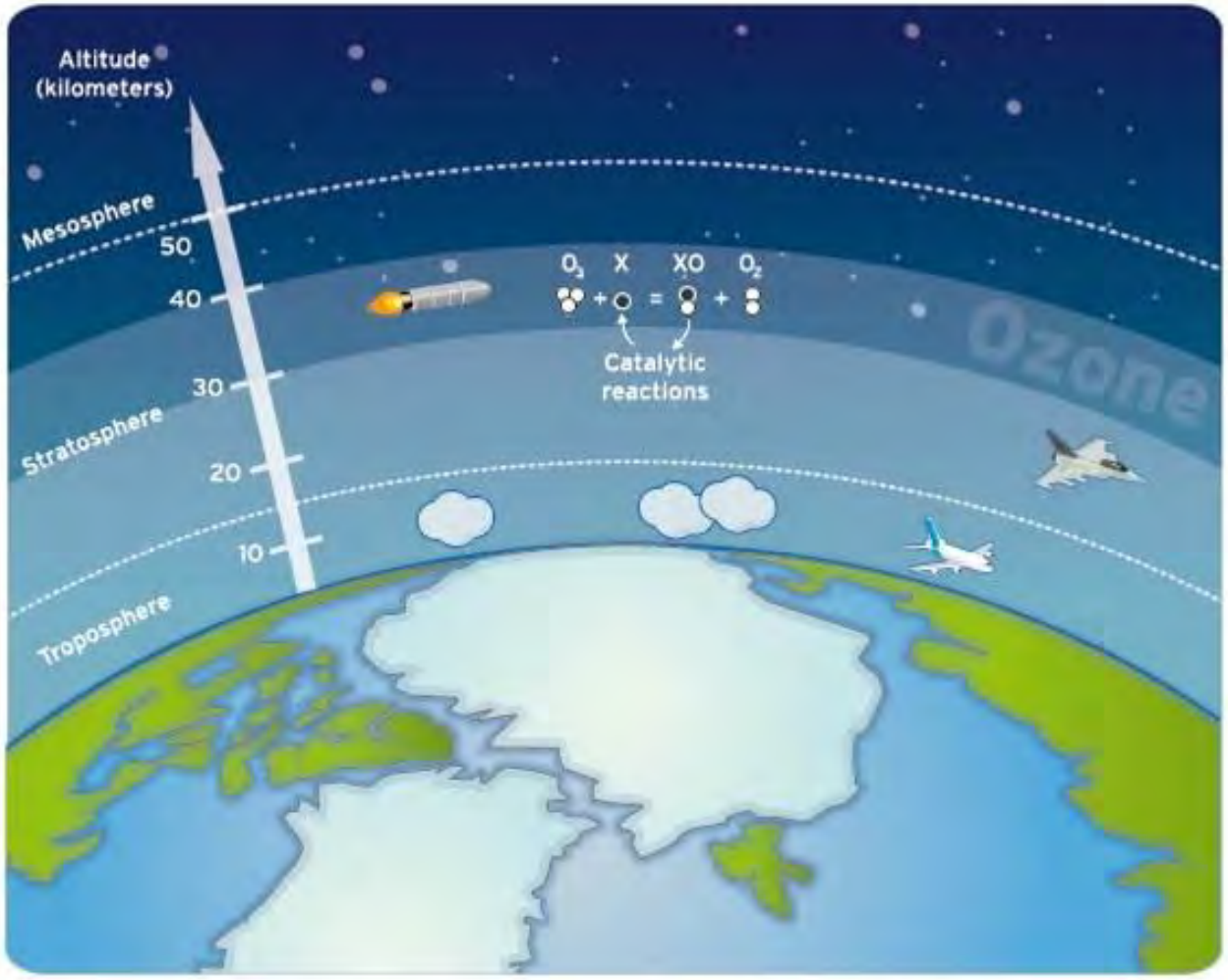
Ozone layer depletion

The ozone layer protect us against ultraviolet radiations

Stratospheric ozone is continuously created and destroyed

Cause

- Anthropogenic emissions (CFC, GHG…)



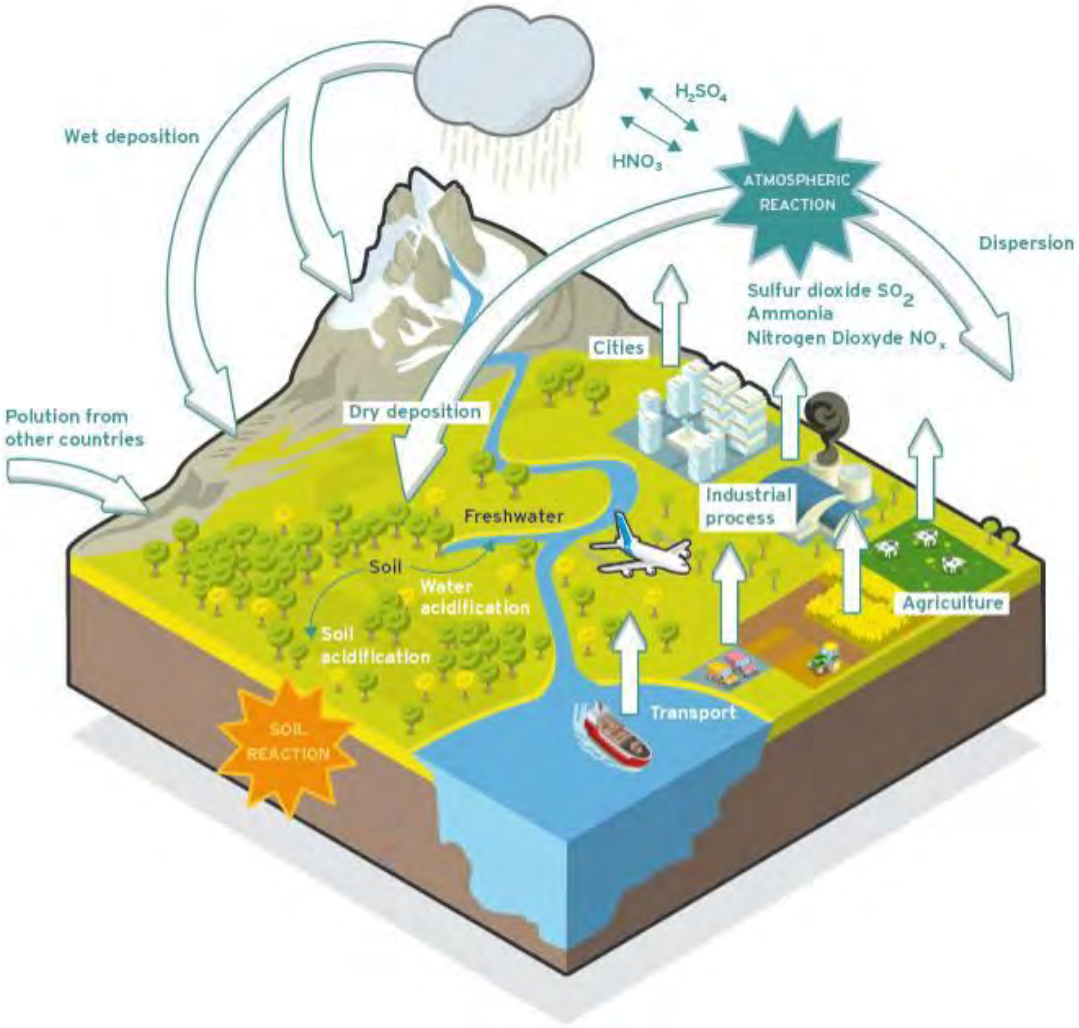
Soil acidification

Impacts on

- Biodiversity (plants)

Cause

- Inorganic substances deposit (sulfate, nitrate, phosphate…)



Water eutrophication

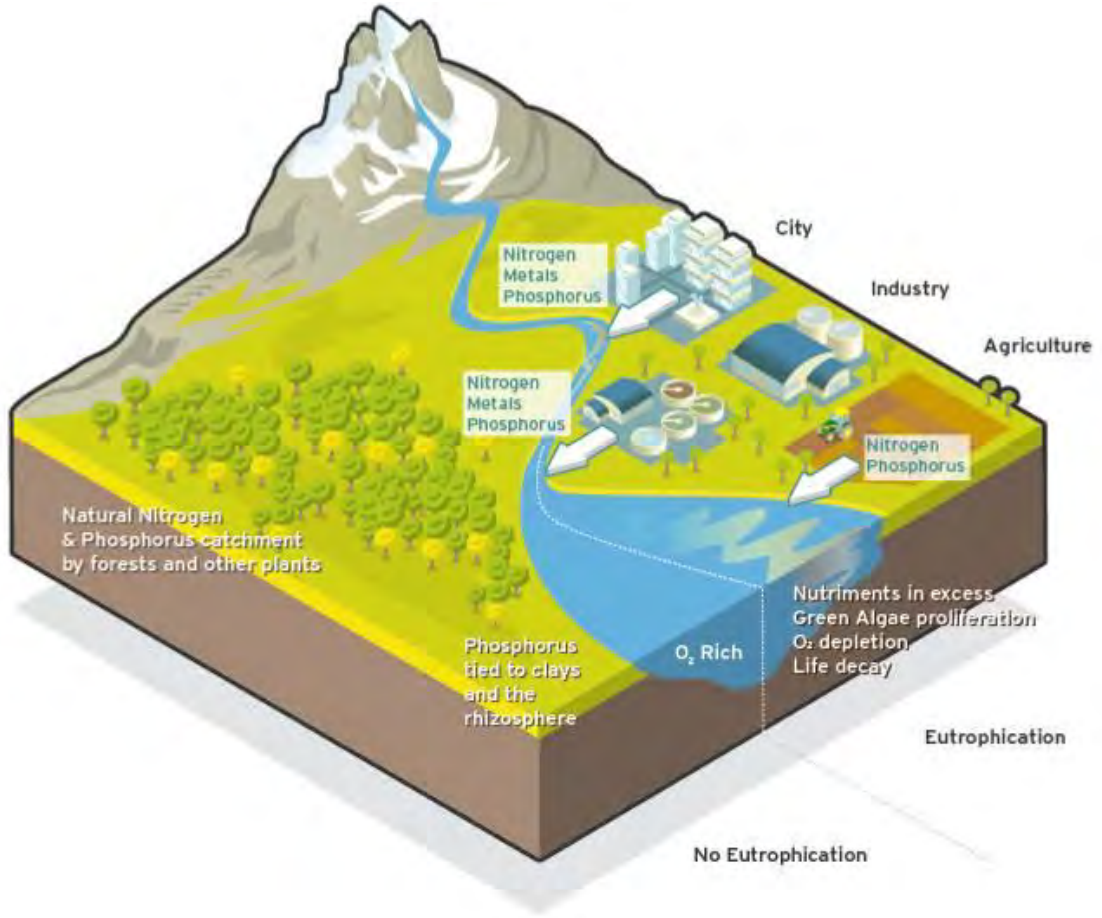
Impact

- Dead zones

Cause

- Nutrient enrichment

Phenomenon based on a complex chain reaction

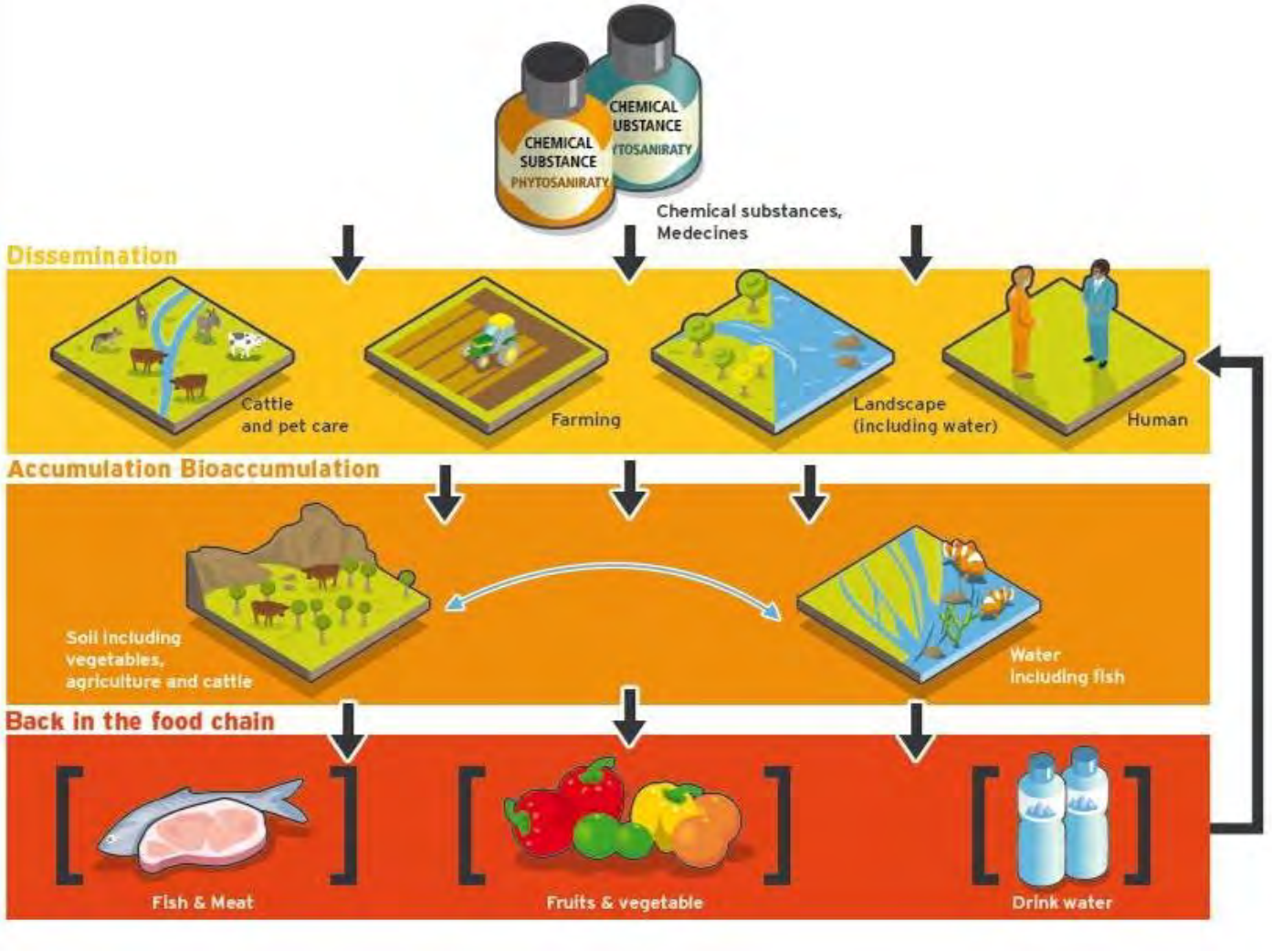


Toxicity

Definition: Toxicity is the degree to which a substance can damage an organism.

Cause

- Chemicals persistence in soils and waters



Damage on human health

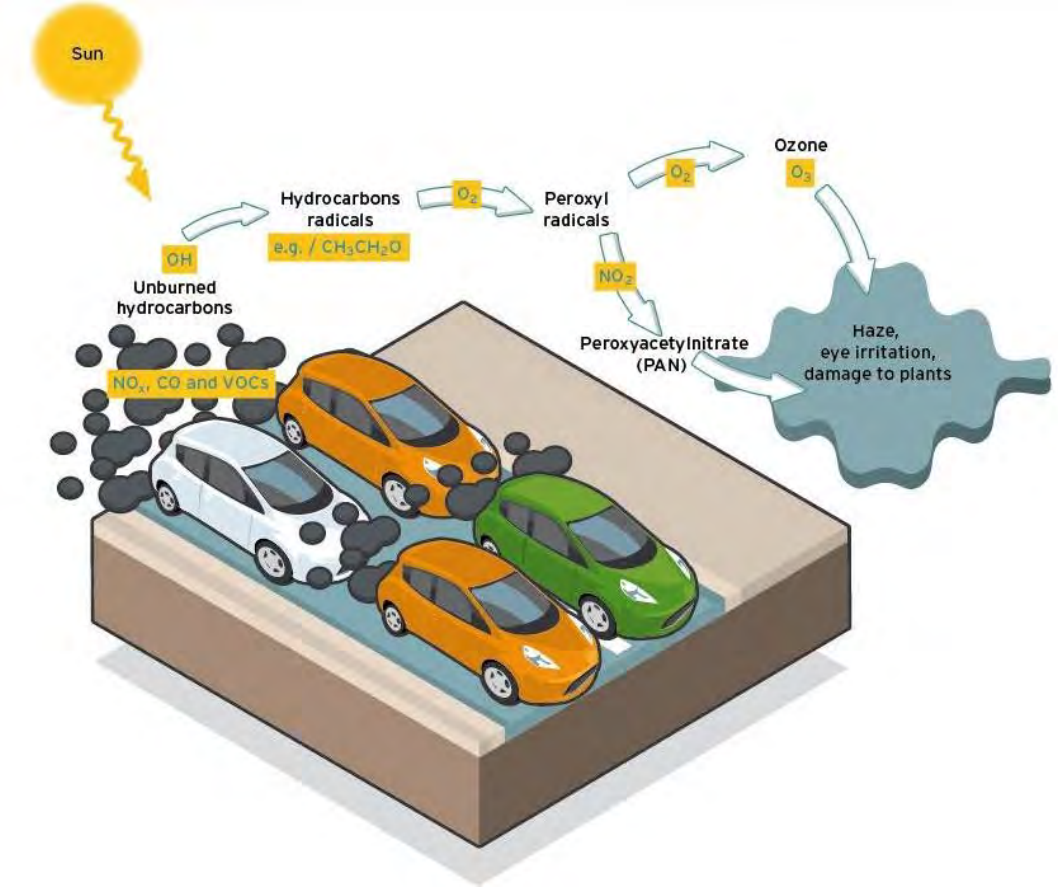
PM_{10}: Particulate Matter < 10 µm

Impacts on

- Human health (respiratory troubles)

Causes

- PM: fossil fuels, cars, aerosols, volcanoes…
- Photochemical ozone: hydrocarbons + solar radiations



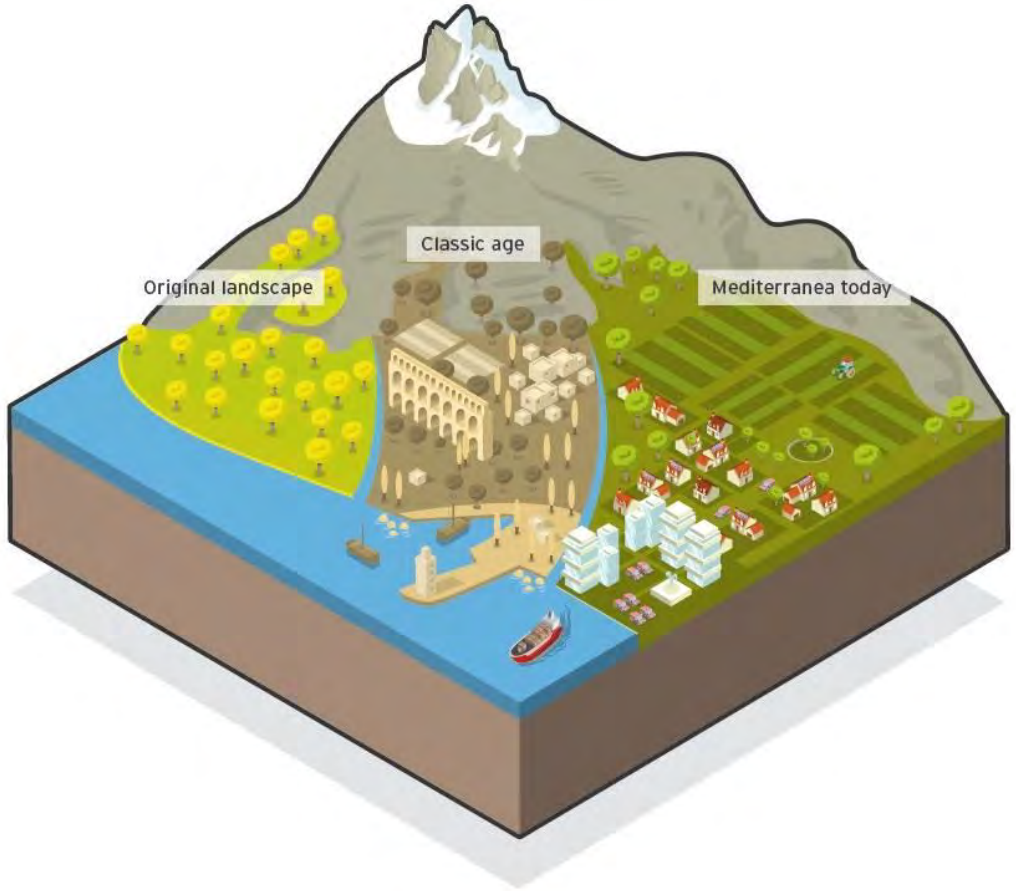
Land use

Impacts on

- Ecosystems

Causes

- Land use
- Land transformations
- Human activities



Use of mineral, fossile, water resources

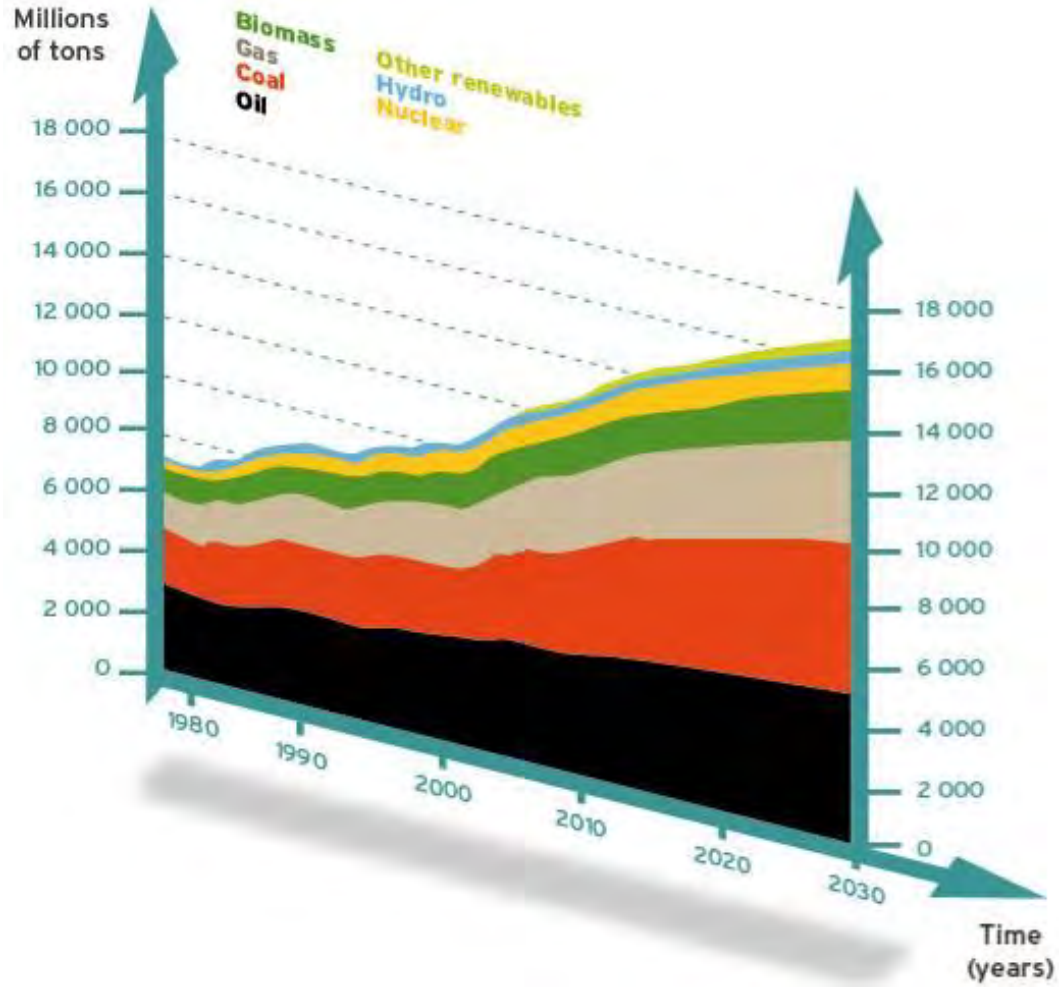
Mineral, fossil and water resources are limited!

Impacts on

- Human activities!

Causes

- Human activities
- Global warming (for water)



Ionising radiations

Includes radioactive emissions

Impacts on

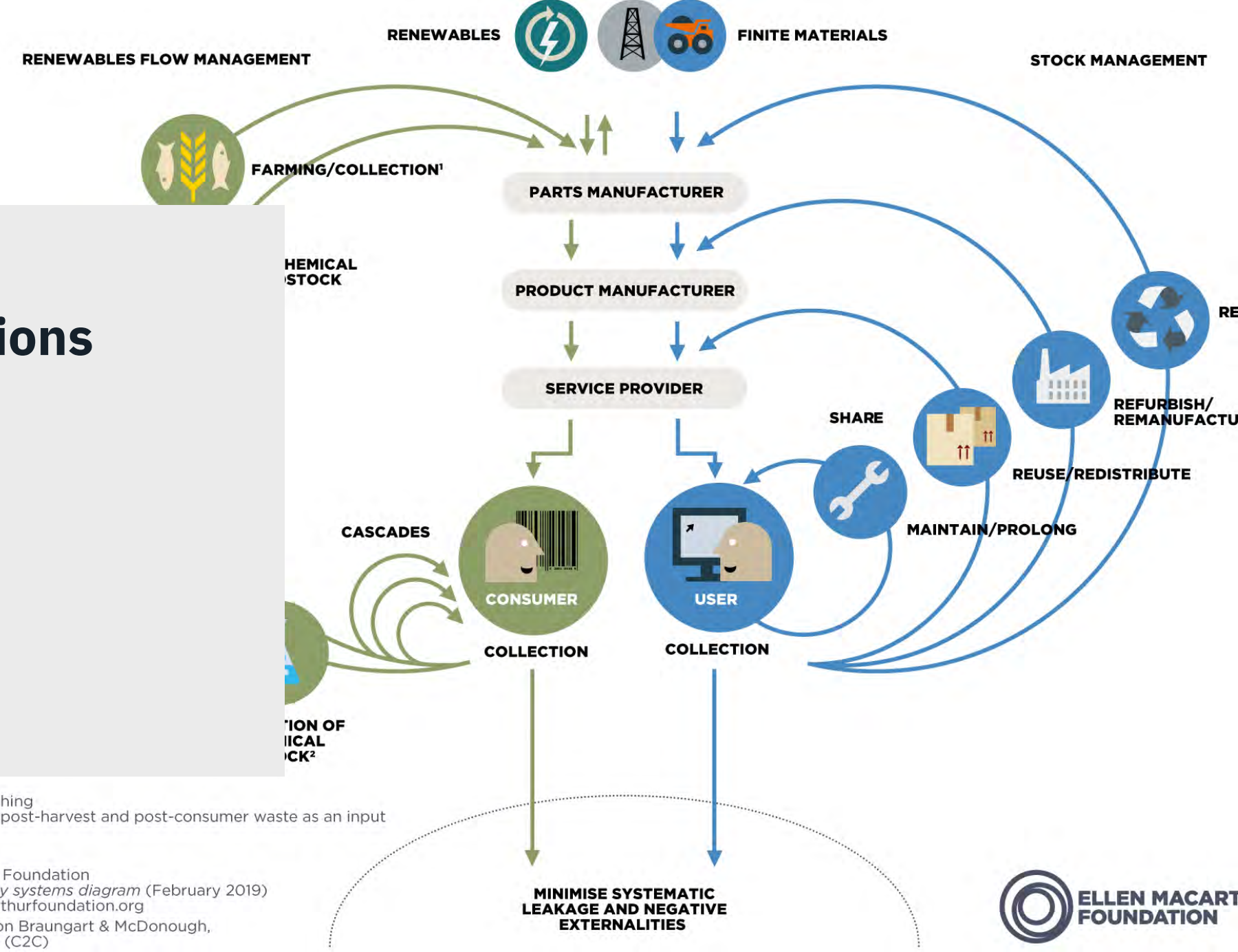
- Ecosystems and human health

Causes

- Nuclear power and wastes

C.

Circular Economy concepts & definitions



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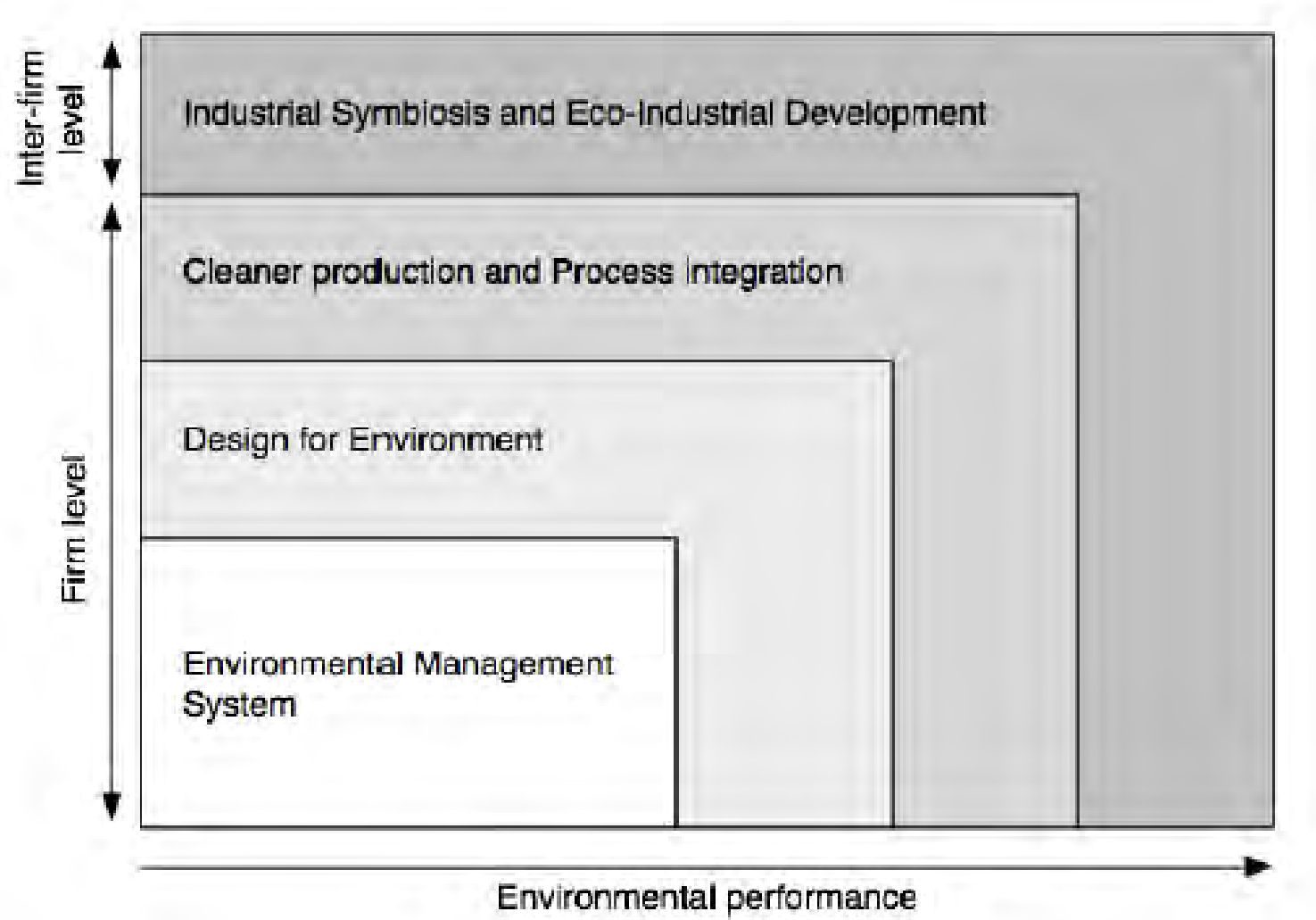
Which answers towards a sustainable development?



Some keywords

Circular economy
Industrial ecology
Product-Service Systems
Eco-innovation
Eco-design
Sustainable design
Design for environment
Life Cycle Assessment
Functional economy
Eco-efficiency
Recycling
Energy efficiency
Sustainable business models
...

A same mindset:

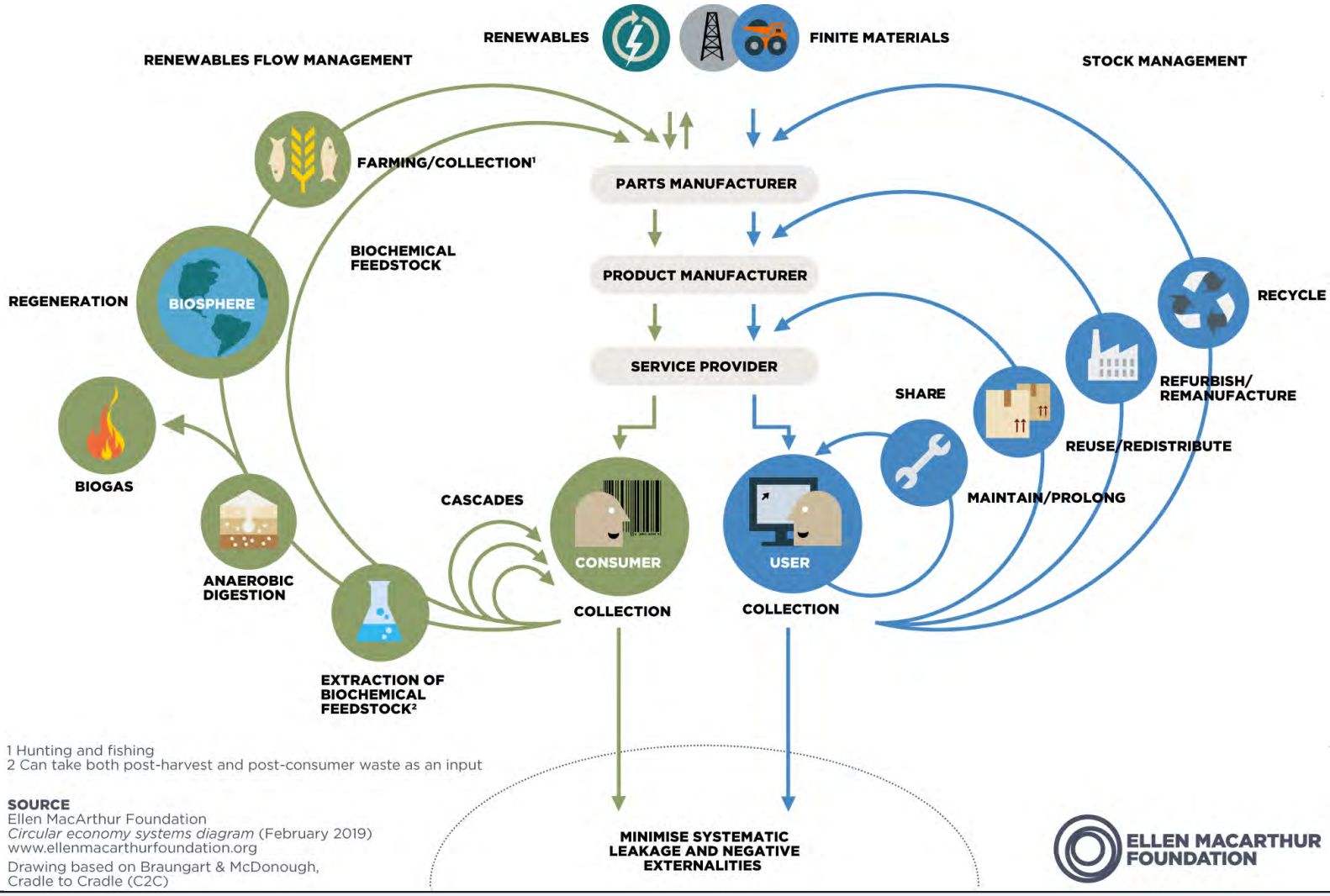
- **Limit environmental impacts**
- **Limit resource consumption**
- **Through innovation**
- **(Including social considerations)**

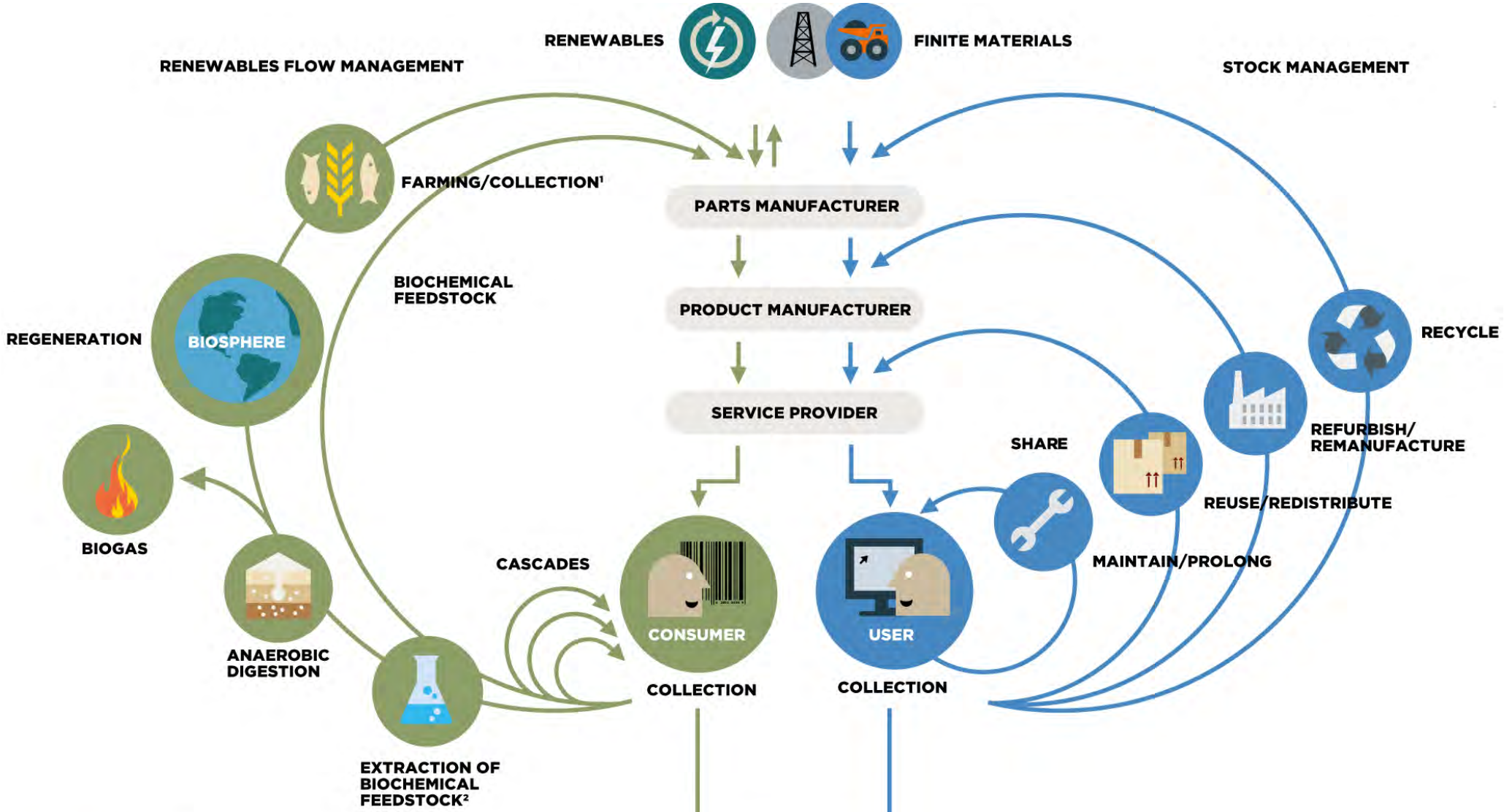
Circular Economy

ONE FIRST DEFINITION

Looking beyond the current "take, make and dispose" extractive industrial model, **the circular economy is restorative and regenerative by design**. Relying on system-wide innovation, it aims to redefine products and services to design waste out, **while minimising negative impacts**. Underpinned by a transition to renewable energy sources, the circular model builds economic, natural and social capital.

[Ellen McArthur Foundation]





1 Hunting and fishing
2 Can take both post-harvest and post-consumer waste as an input

SOURCE
Ellen MacArthur Foundation
Circular economy systems diagram (February 2019)
www.ellenmacarthurfoundation.org
Drawing based on Braungart & McDonough, Cradle to Cradle (C2C)

ELLEN MACARTHUR FOUNDATION

Circular Economy

A SECOND DEFINITION

There is currently no standard definition of Circular Economy.

According to ADEME, the circular economy is “an **economic system** for exchange and production which, at **all stages of the product life cycle** (goods and services), aims to increase the **efficiency of resource use** and **reduce the impact on the environment**, while enabling people to **live well**.”

[ADEME 2014]

ADEME

Agence de l'Environnement et de la Maîtrise de l'Energie

Circular Economy

SEVERAL DEFINITIONS

Sources	Définitions de l'Economie Circulaire
Ministère de l'environnement	Concept économique qui s'inscrit dans le cadre du développement durable et dont l'objectif est de **produire des biens et des services tout en limitant la consommation et le gaspillage des matières premières, de l'eau et des sources d'énergie**. Il s'agit de déployer, une nouvelle économie, circulaire, et non plus linéaire, fondée sur le principe de « refermer le **cycle de vie** » des produits, des services, des déchets, des matériaux, de l'eau et de l'énergie. Source : [site du ministère de l'environnement]
Conseil Economique, Social et Environnemental (CESE)	Le concept d'économie circulaire consiste à rechercher au maximum la **réutilisation des sous-produits de chaque processus de production ou de consommation** pour réintégrer ces derniers et éviter leur dégradation en déchets, **en les considérants comme des ressources potentielles**. Ce concept englobe la **réduction de déchets** en amont par l'**écoconception** des produits, le remplacement de la vente de produits par la vente de services ou la location (**économie de fonctionnalité**), peu génératrices de déchets, le **réemploi** et enfin le **recyclage**. Source : [Attar 08]
Agence de l'environnement et de la maitrise de l'énergie (ADEME)	**Système économique** d'échange et de production qui, à **tous les stades du cycle de vie des produits** (biens et services), vise à **augmenter l'efficacité de l'utilisation des ressources** et à **diminuer l'impact sur l'environnement**, tout en développant le bien être des individus. Source : [Geldron 13]
Fondation Ellen MacArthur	**Economie industrielle** qui est, à dessein ou par intention, **réparatrice** et dans laquelle les flux de matières sont de deux types bien séparés ; les **nutriments biologiques**, destinés à ré-entrer dans la biosphère en toute sécurité, et des **entrants techniques** (« technical nutrients »), conçus pour être recyclés en restant à haut niveau de qualité, sans entrer dans la biosphère. Source : [site de la fondation Ellen MacArthur]

L'économie circulaire

3 domaines, 7 piliers

[ADEME 2014]

Circular Economy & Industrial Ecology

DIFFERENT POINTS OF VIEW

For ADEME

- Industrial and Territorial Ecology (EIT) is one of the 7 pillars
- EIT reduced to the dimension of industrial symbioses and eco-industrial parks

For Suren Erkman

- Circular Economy and Industrial Ecology = synonyms
- Industrial ~~and Territorial~~ Ecology → The notion of territory is underlying
- Circular Economy = more common in France
- Industrial Ecology = more common abroad

For Institut National de l'Economie Circulaire

- **Industrial Ecology = scientific field of Circular Economy aiming at reinstating industrial activities in the biosphere limits**

Point of view in this course

Circular Economy & Sustainability

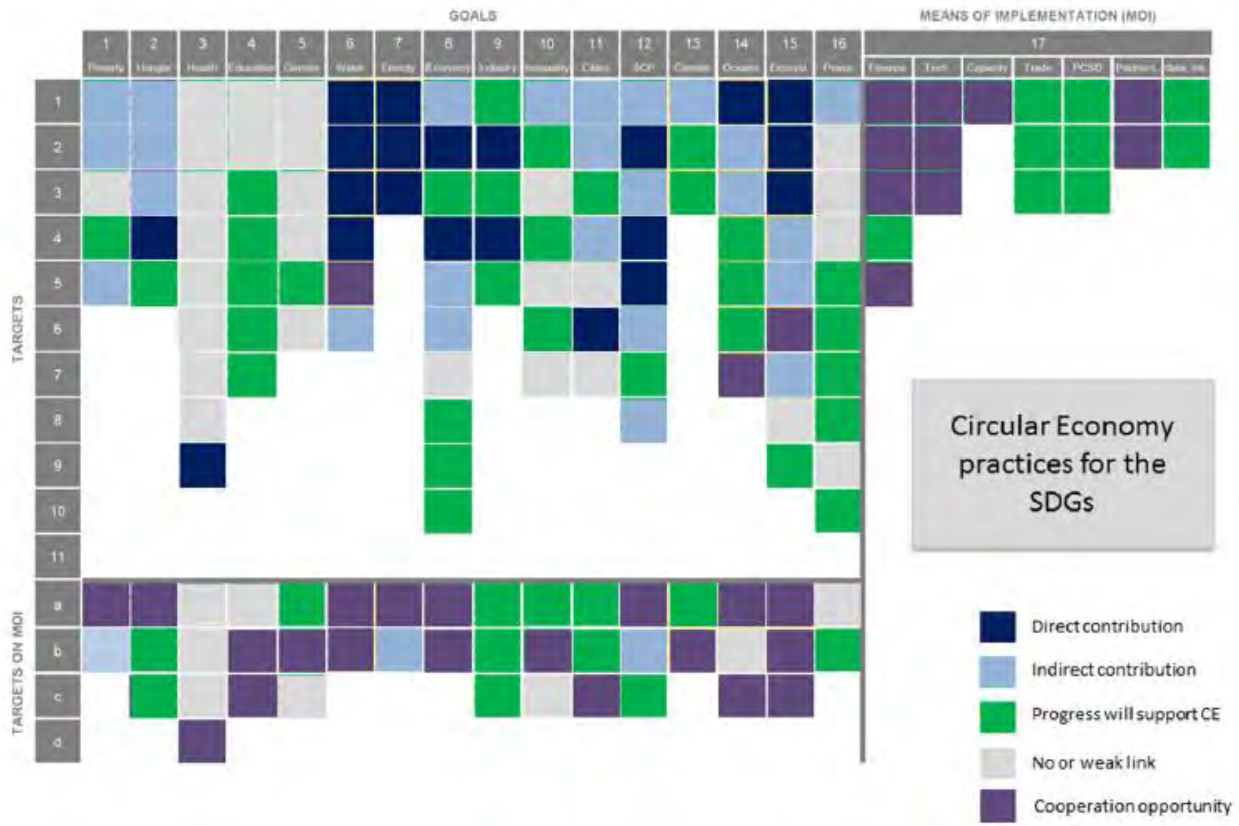


Figure 3 Relationship between circular economy (CE) practices and 169 Sustainable Development Goals (SDG) targets (visual presentation adapted from OECD 2015b).

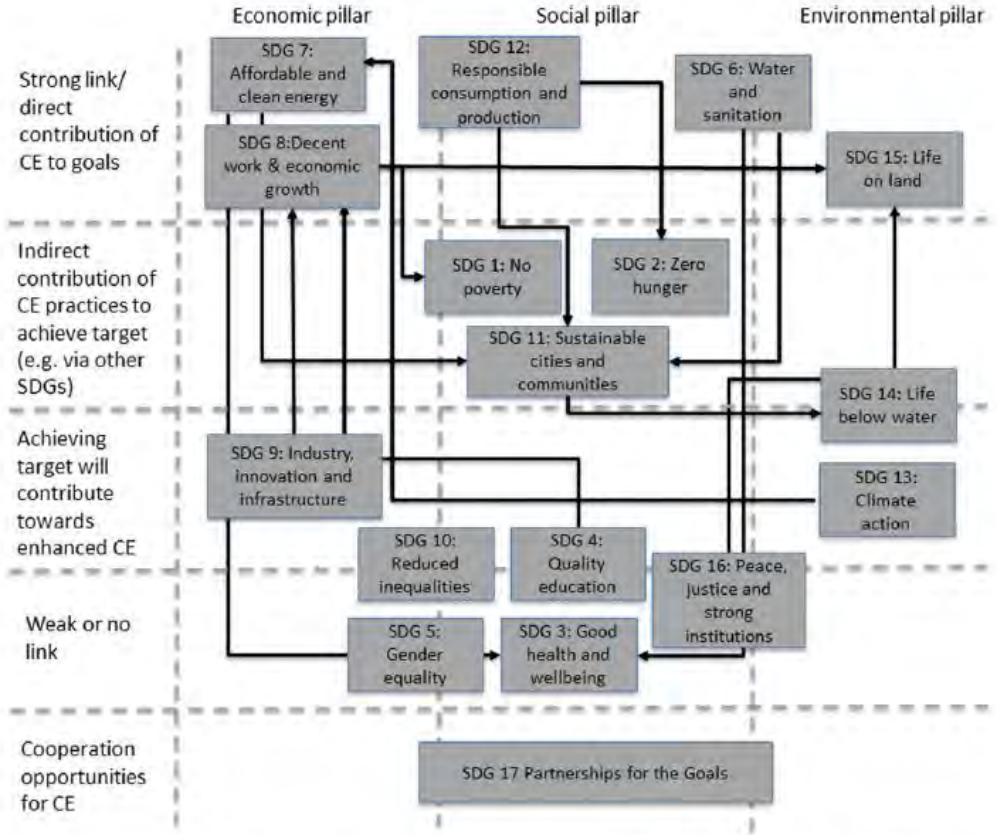


Figure 4 Relationships between Sustainable Development Goals (SDGs) in the context of circular economy (CE) practices.

[Schroeder et al. 2018]

Circular Economy & Sustainability

[Schroeder et al. 2018]

Ecodesign and longer duration of life

A

Context and definitions

L'économie circulaire

3 domaines, 7 piliers

[ADEME 2014]

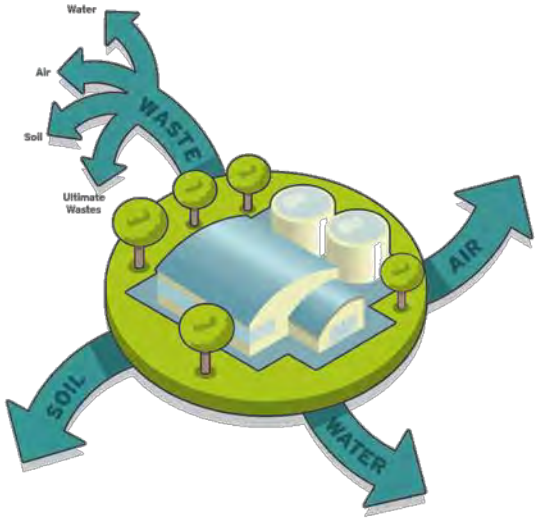
Triggers for ecodesign adoption

Ecodesign

DEFINITION

Ecodesign is the **systematic consideration** of **environmental issues** in product, services, system design process

Ecodesign is a **multicriteria approach** over the **entire life cycle of system**



[FD X30-310:1998]
[ISO/TR 14062:2003]

Ecodesign pillars

5 MAIN PRINCIPLES

1. Une **prise en compte globale** de l'environnement

2. **Intégration** de la dimension environnementale dans les méthodes de conception

3. Utilisation de **méthodes et d'outils d'évaluation**

4. **Combinaison de stratégies** de réduction des impacts potentiels

5. **Le dialogue et le partenariat**

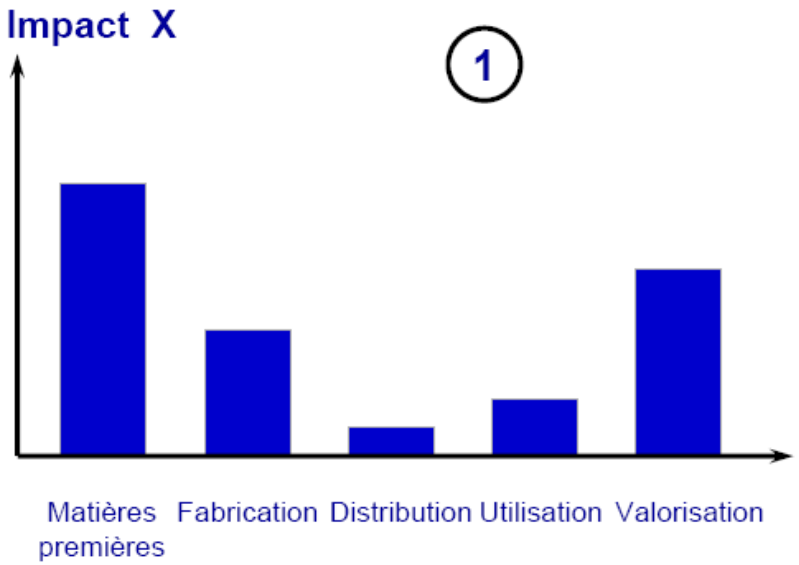
[FD X30-310:1998]
[ISO/TR 14062:2003]

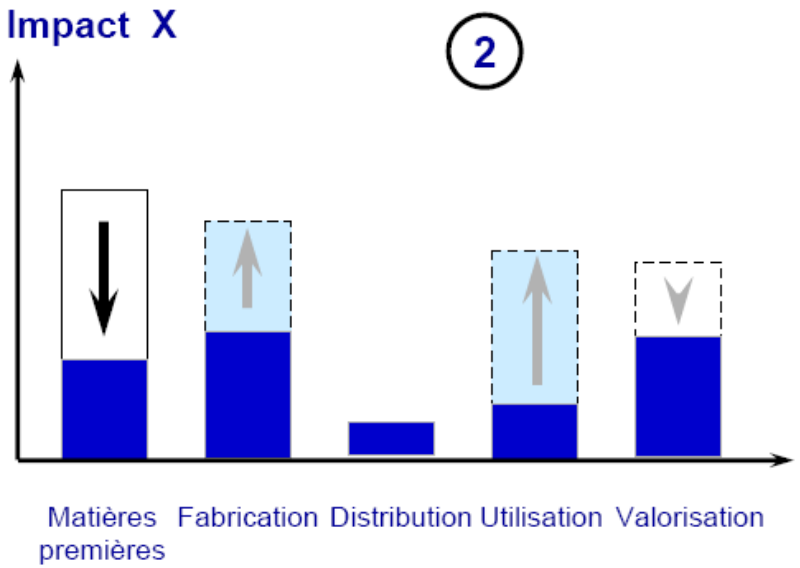
Integration of environmental issues

Multi criteria

Multi-phases

Multi-impacts



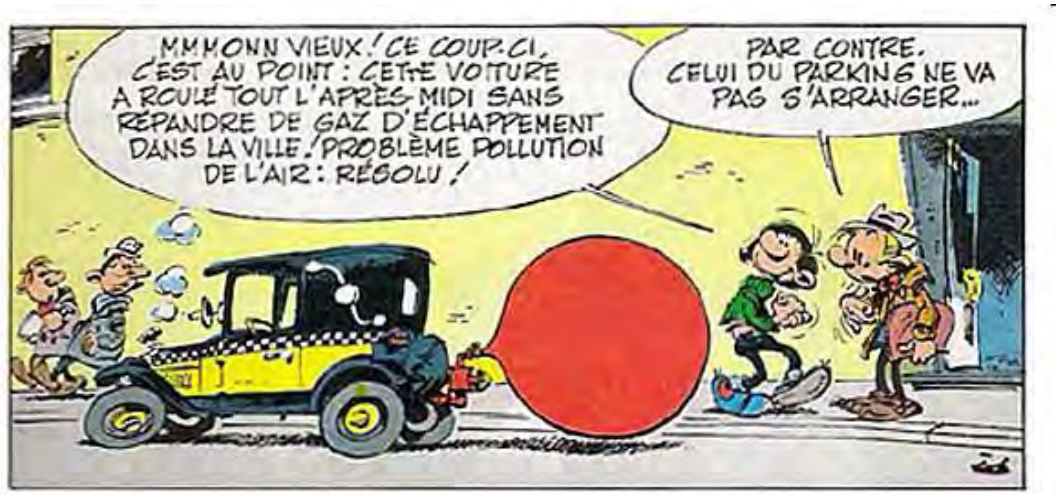


The main environmental concerns

ENVIRONMENTAL PROTECTION IS NOT LIMITED TO CO2 EMISSIONS RESTRICTION!

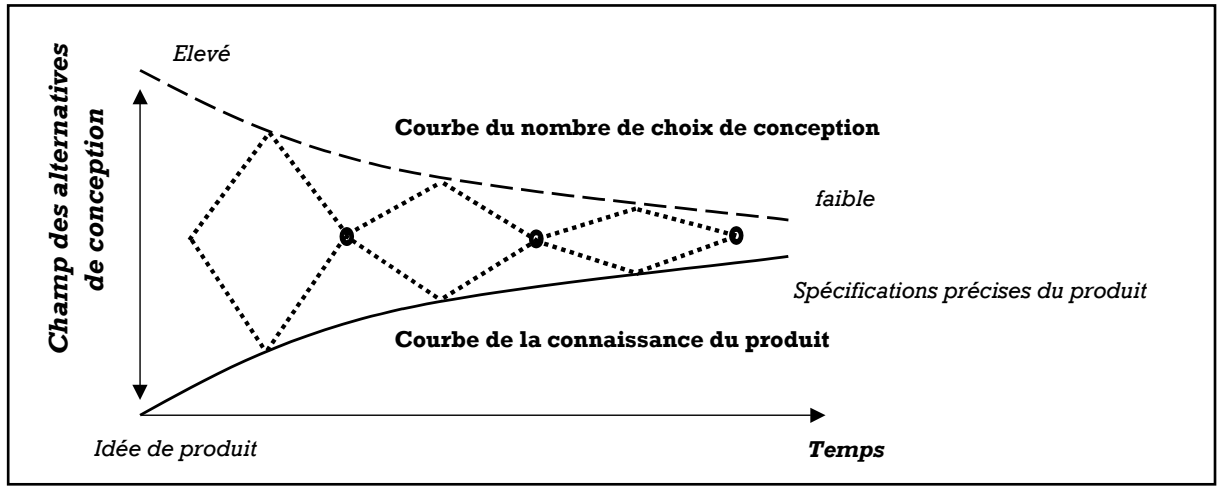
7 main environmental impact categories

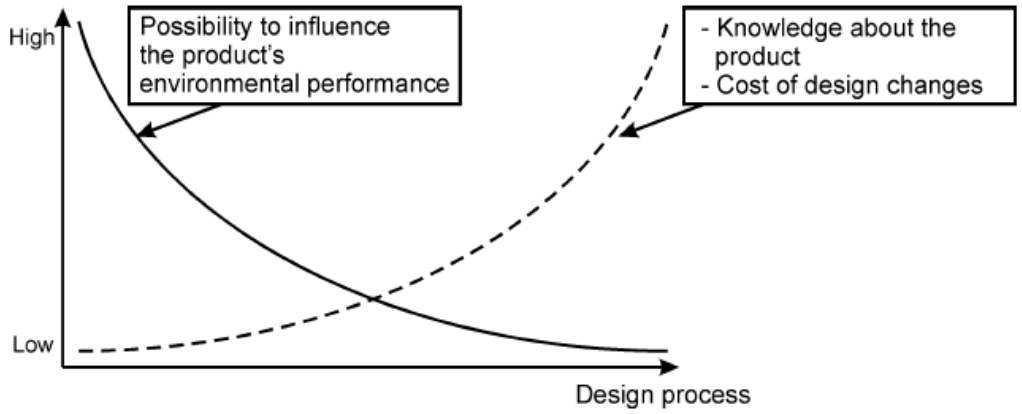
- Raw materials
- Hazardous substances
- Energy
- Air pollution
- Water pollution
- Soils pollution
- Wastes



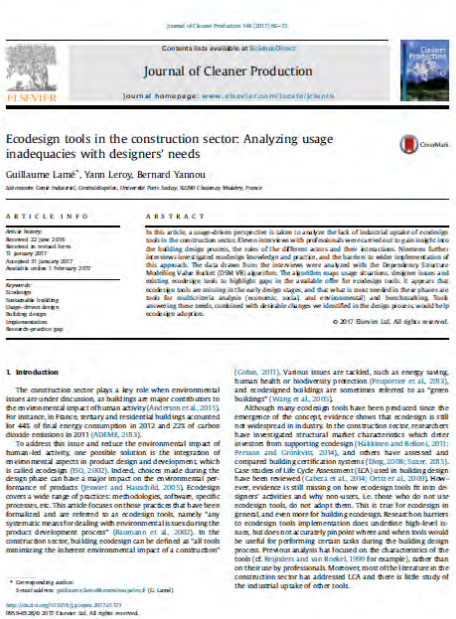
Main environmental mechanisms associated to those categories

Integration at early stage of development





Method and tools



Journal of Cleaner Production

Ecodesign tools in the construction sector: Analyzing usage inadequacies with designers' needs

Guillaume Lamé*, Yann Leroy, Bernard Yannou

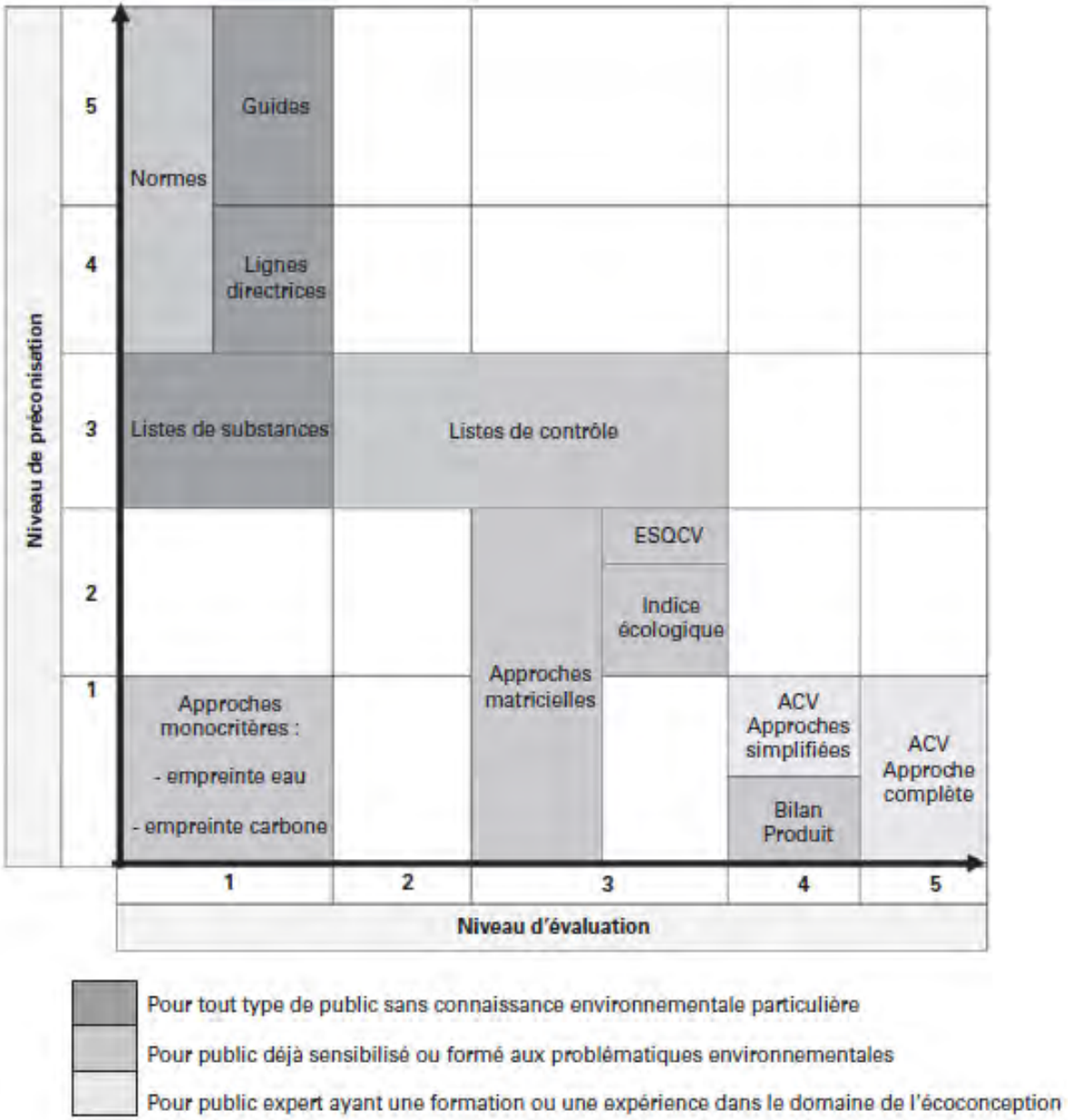
1. Introduction

The construction sector plays a key role when environmental issues are under discussion, as buildings are major contributors to the environmental impact of human activity (Anderson et al., 2011). For instance, in France, tertiary and residential buildings accounted for 44% of final energy consumption in 2012 and 22% of carbon dioxide emissions in 2013 (ADEME, 2013).

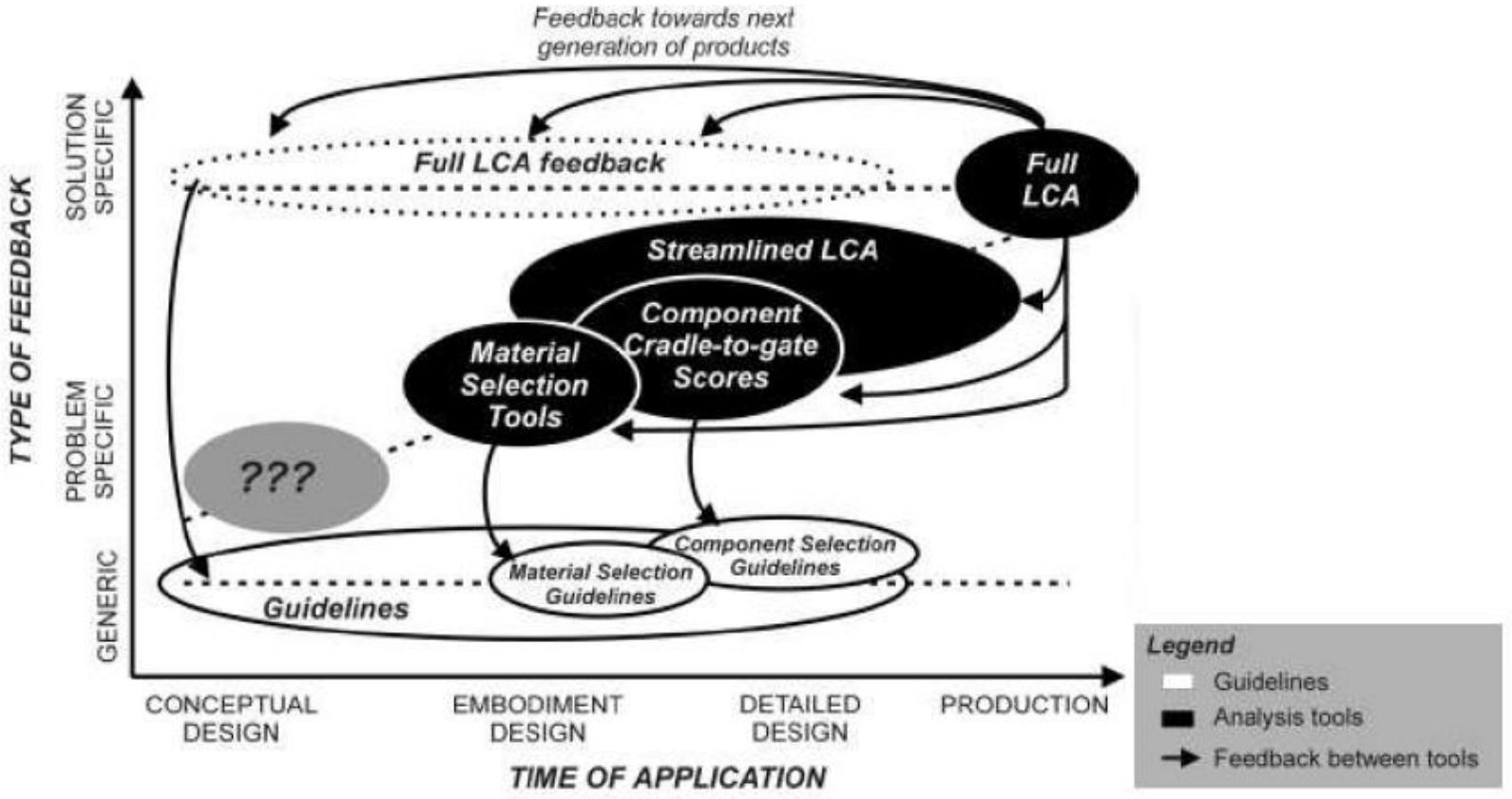
To address this issue and reduce the environmental impact of human-led activity, one possible solution is the integration of environmental aspects in product design and development, which is called ecodesign (ISO, 2002). Indeed, choices made during the design phase can have a major impact on the environmental performance of products (Jewell and Hauschild, 2005). Ecodesign covers a wide range of practices: methodologies, software, specific processes, etc. This article focuses on those practices that have been formalized and are referred to as ecodesign tools, namely "any systematic means for dealing with environmental issues during the product development process" (Baumann et al., 2002). In the construction sector, building ecodesign can be defined as "all tools minimizing the inherent environmental impact of a construction" (Cobin, 2011). Various issues are tackled, such as energy saving, human health or biodiversity protection (Peuportier et al., 2014), and ecodesigned buildings are sometimes referred to as "green buildings" (Wang et al., 2010).

Although many ecodesign tools have been produced since the emergence of the concept, evidence shows that ecodesign is still not widespread in industry. In the construction sector, researchers have investigated structural market characteristics which deter investors from supporting ecodesign (Häkkinen and Belloni, 2011; Persson and Grönkvist, 2014), and others have assessed and compared building certification systems (Ding, 2008; Suzer, 2015). Case studies of Life Cycle Assessment (LCA) used in building design have been reviewed (Cabeza et al., 2014; Ortiz et al., 2010). However, evidence is still missing on how ecodesign tools fit into designers' activities and why non-users, i.e. those who do not use ecodesign tools, do not adopt them. This is true for ecodesign in general, and even more for building ecodesign. Research on barriers to ecodesign tools implementation does underline high-level issues, but does not accurately pinpoint where and when tools would be useful for performing certain tasks during the building design process. Previous analysis has focused on the characteristics of the tools (cf. Reijnders and van Roekel, 1999 for example), rather than on their use by professionals. Moreover, most of the literature in the construction sector has addressed LCA and there is little study of the industrial uptake of other tools.

(Bellini & Janin 2011)

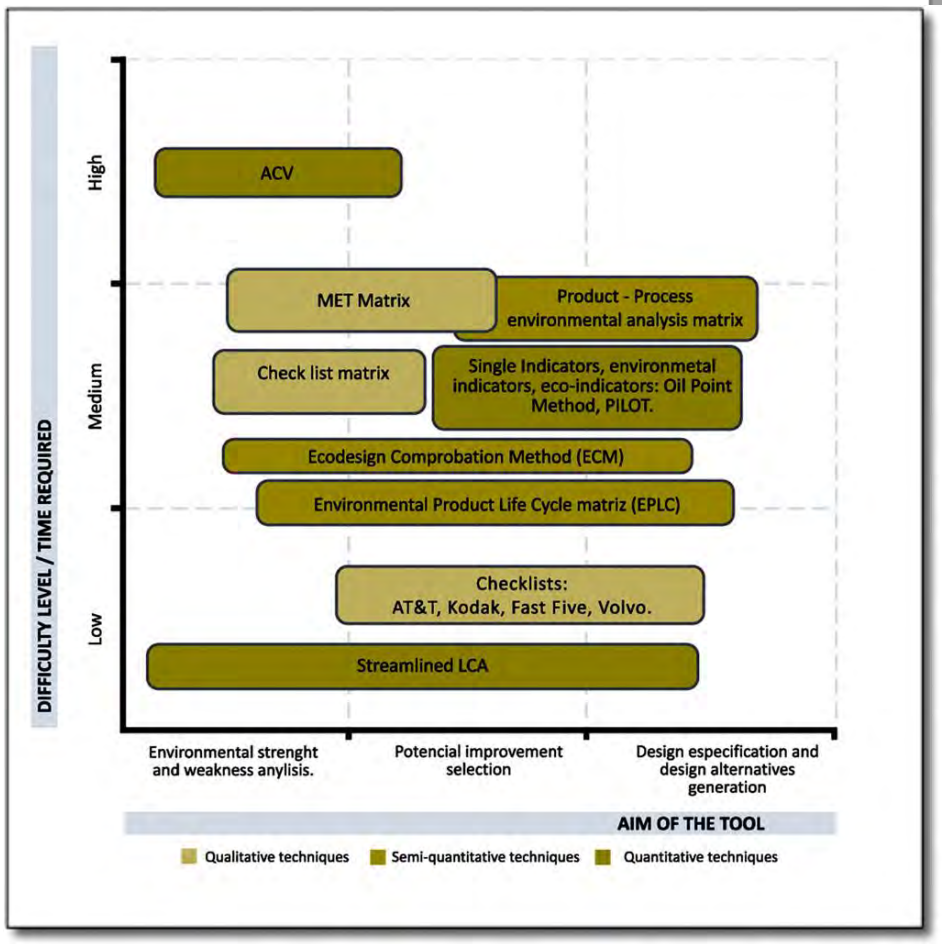


Interconnexion

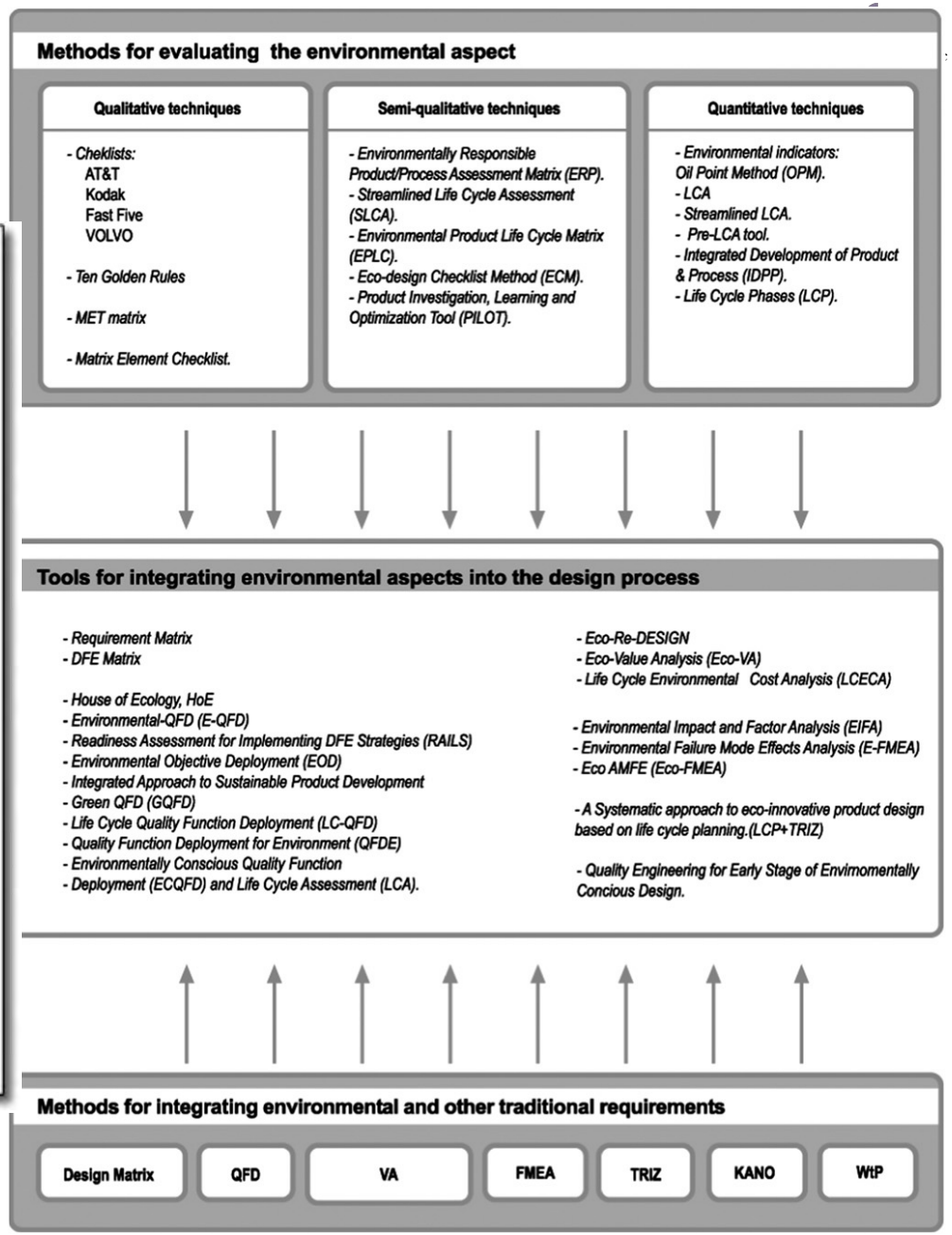


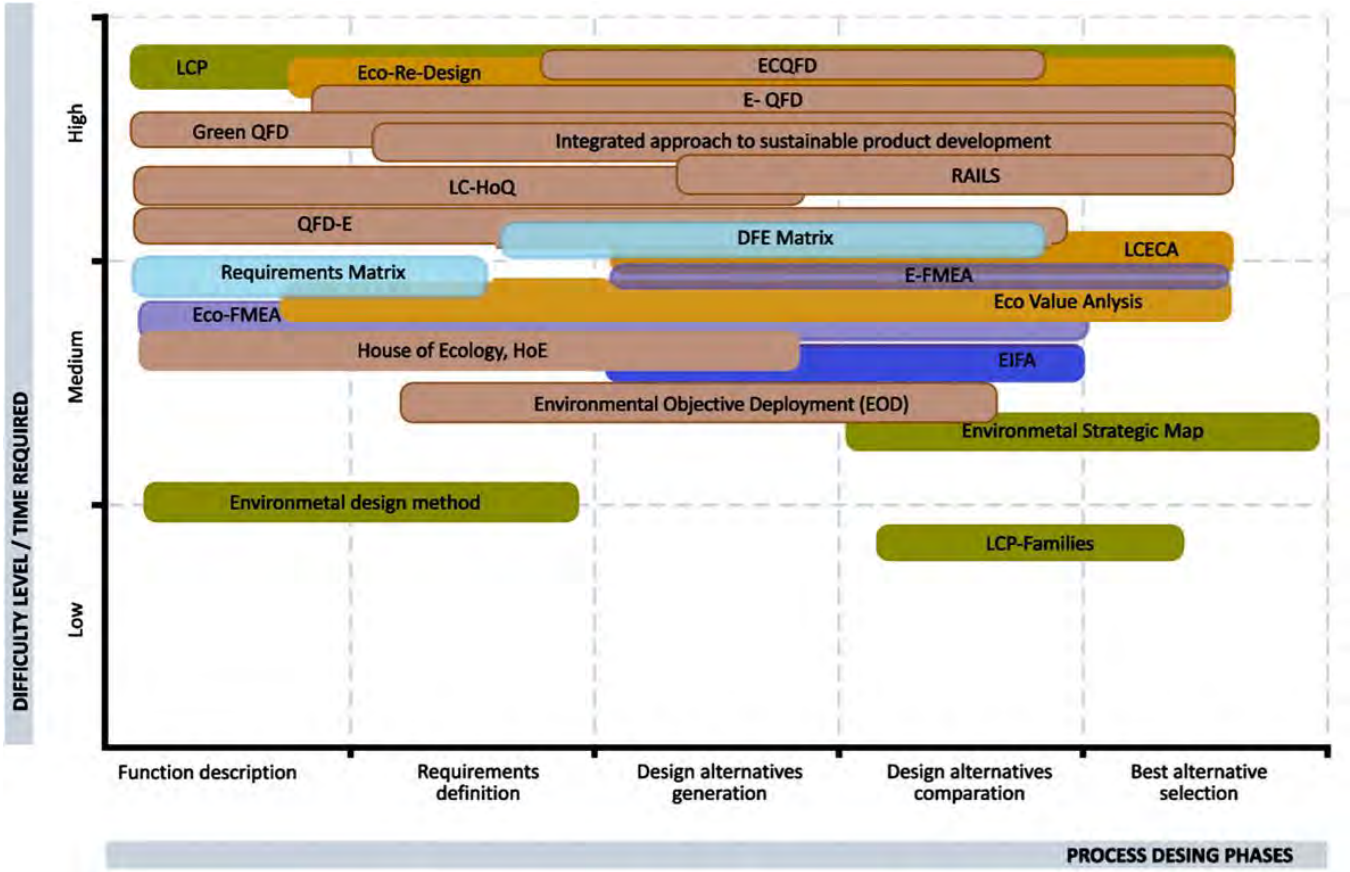
[Dewulf 2003]

Method and tools



Bovea & Perez-Belis 2012





BASED ON MATRIX DESIGN

Requeriments Matrix
DFE Matrix

BASED ON QFD

House of Ecology
Environmental QFD
Readiness assessment for implementing DFE strategies.
Environment Objective Deployment (EOD)
Integrated Approach to Sustainable Product Development.
Green QFD
Life Cycle House of Quality (LC-HoQ)
Quality Function Deployment for Environment (QFD-E)
Environmentally Conscious Quality Function Deployment (ECQFD)

BASED ON ANALYSIS VALUE

Eco-Re-Design
Eco-Value Analysis Eco-Va
Life Cycle Environmental Cost Analysis (LCECA)

BASED ON FMEA

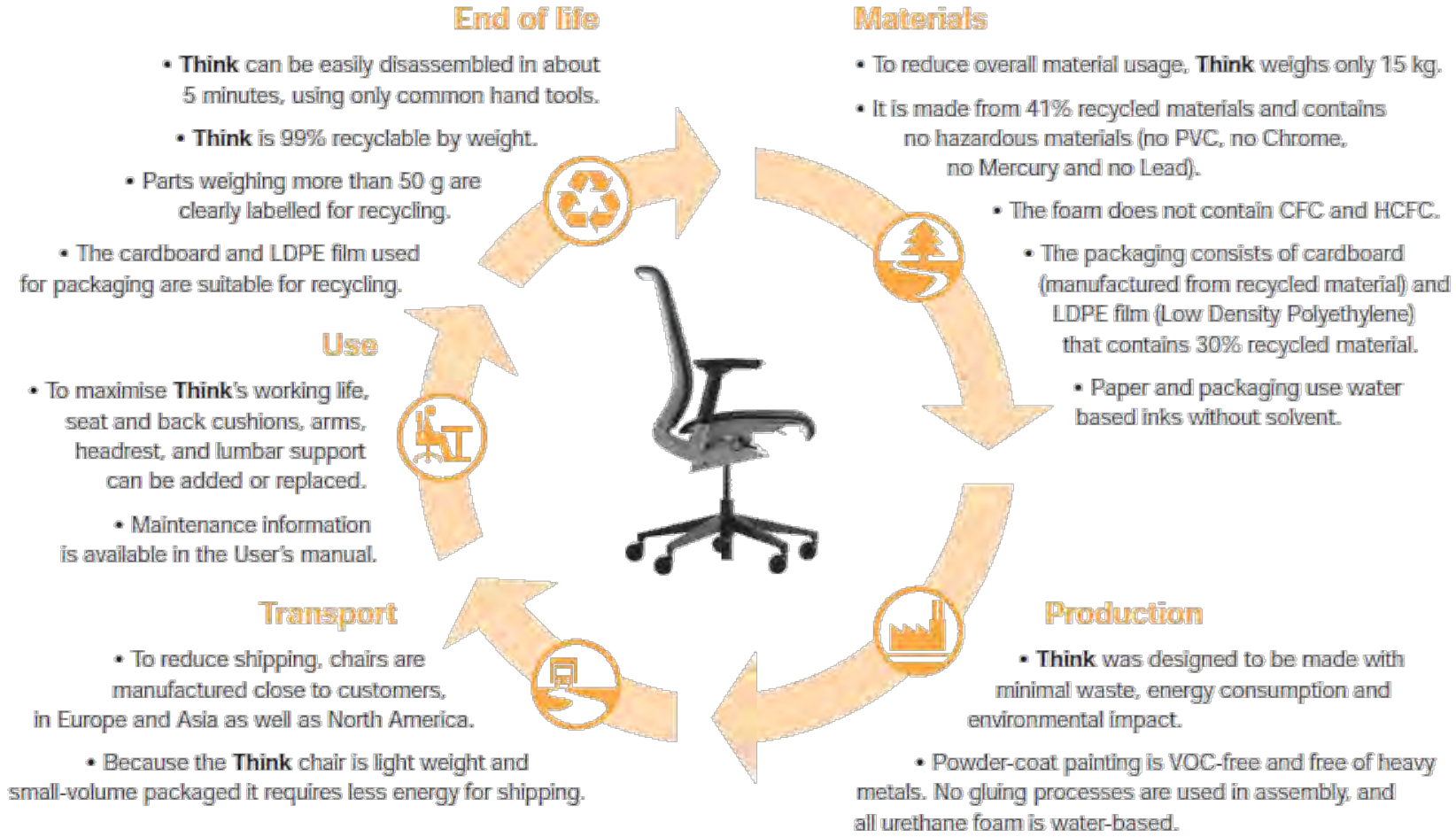
Environmental Impact and Factor Analysis EIFA
Environmental FMEA, E-FMEA
Eco-FMEA

OTHERS

LCP-Families
Life Cycle Planning LCP
Quality Engineering for early stage of environmentally Conscious Design
Environmental Performance Strategy Map, EPSM

Few examples

Steelcase



Few examples

One
Understand your environmental impacts and set goals to reduce them.

Two
Embrace print on demand.

Three
Utilize soft proofing.

Four
Adopt latest workflow technologies.

Five
Make the most of every sheet.

Six
Know where your paper comes from and recycle the paper you use.

Seven
Reduce energy use.

Eight
Use good waste prevention and management practices.

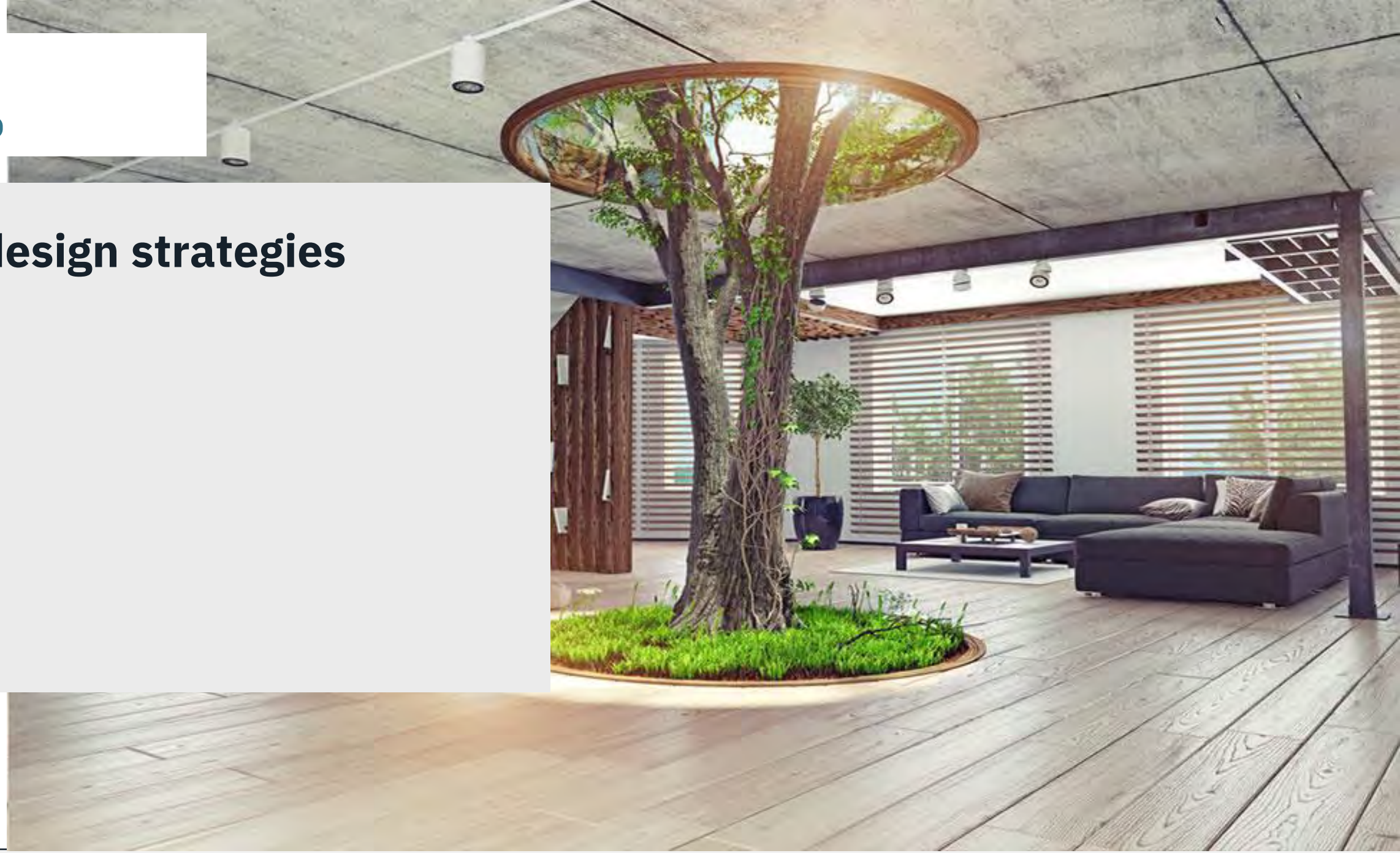
Nine
Seek equipment designed for remanufacturing or recycling.

Ten
Ensure you're working with environmentally responsible suppliers.

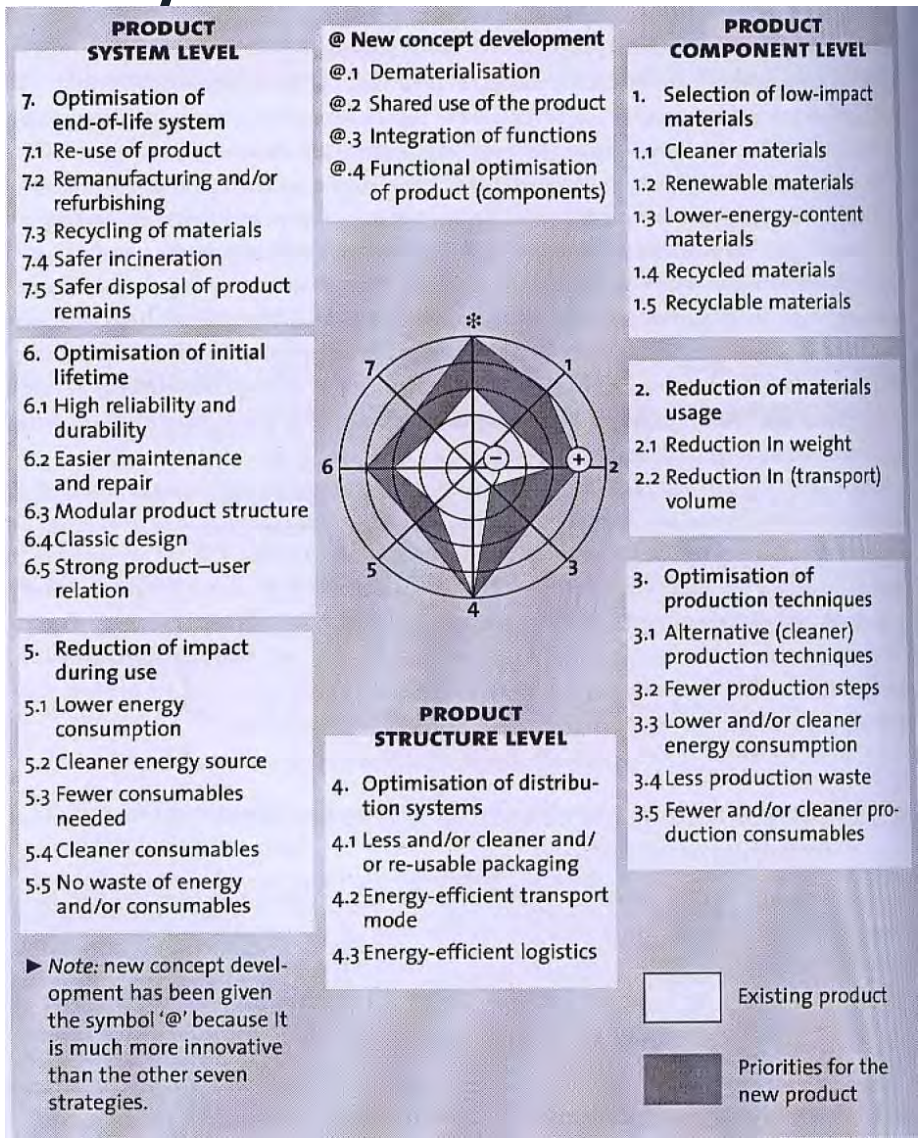
For more information, please go to www.xerox.com/digital-printing

B.

Ecodesign strategies



The eco-design strategy wheel/LiDS wheel



[Brezet & Van Hemel 1997]

1. Selection of low-impact materials

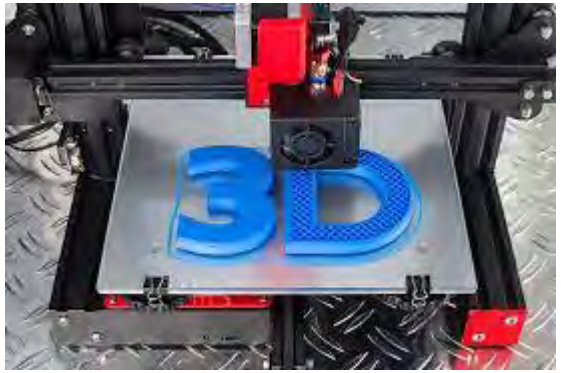
- Cleaner materials
- Renewable materials
- Lower-energy-content materials
- Recycled materials
- Recyclable materials

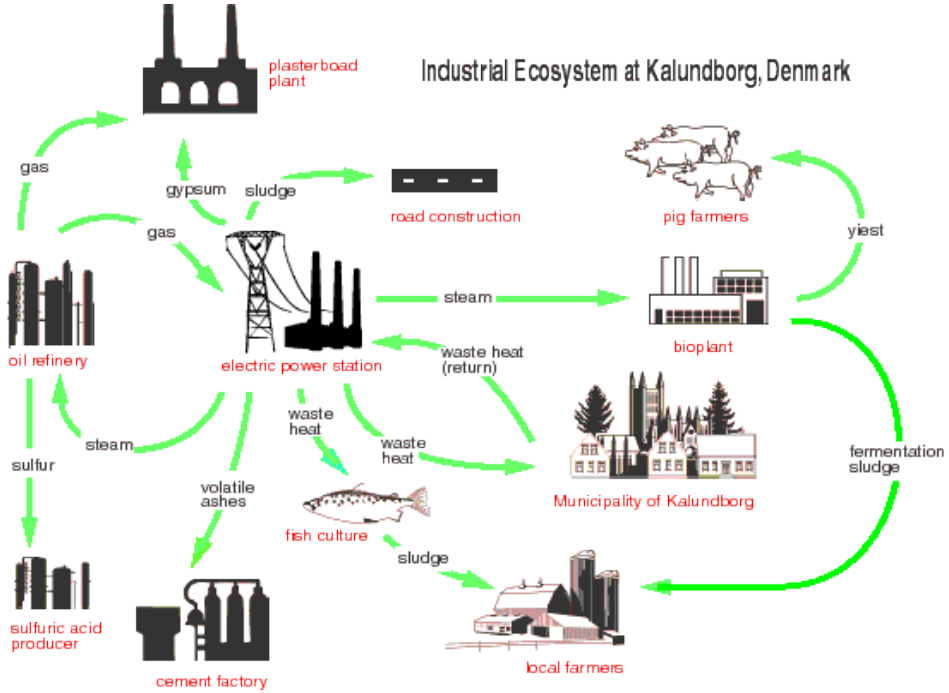
2. Reduction of materials usage

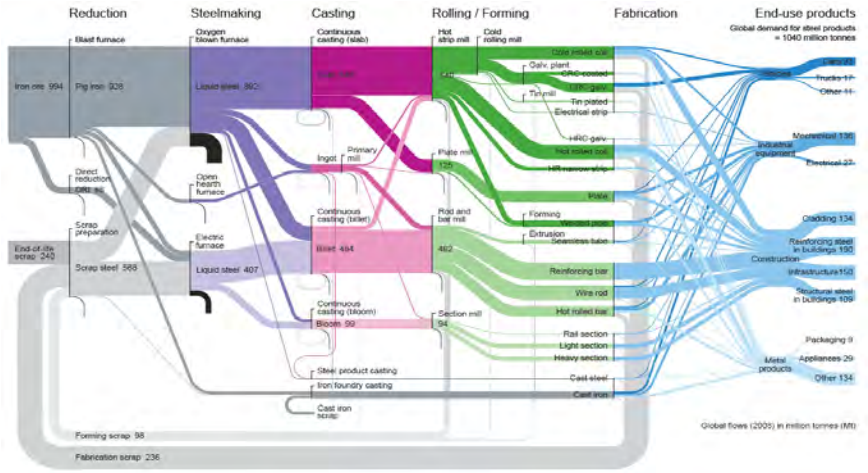
- Reduction in weight
- Reduction in (transport) volume
- Reduction of the number of materials

3. Optimisation of production techniques

- Alternative (cleaner) production techniques
- Fewer production steps
- Lower and/or cleaner energy consumption
- Less production waste
- Fewer and/or cleaner production consumables





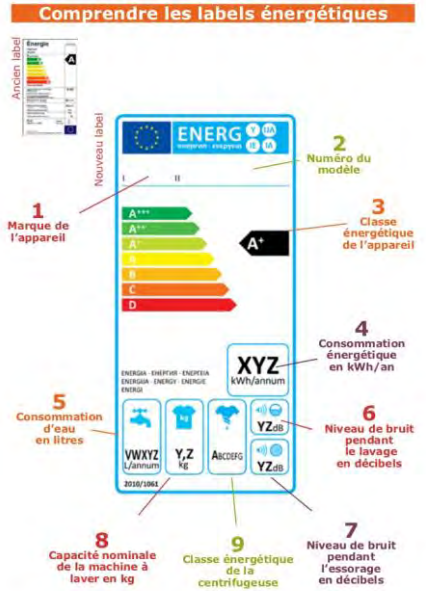


4. Optimisation of distribution system

- Less and/or cleaner and/or reusable packaging
- Energy-efficient transport mode
- Energy-efficient logistics

5. Reduction of impact during use

- Lower energy consumption
- Cleaner energy source
- Fewer consumables needed
- Cleaner consumables
- No waste of energy and/or consumables

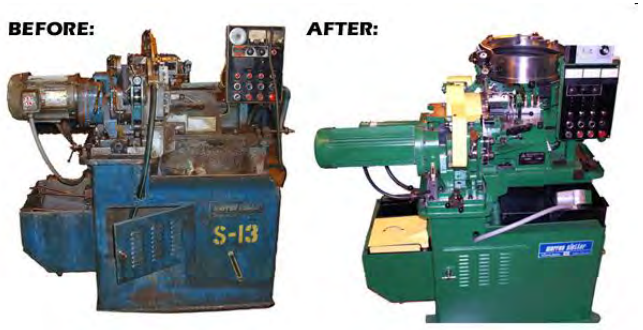


6. Optimisation of initial lifetime

- High reliability and durability
- Easier maintenance and repair
- Modular product structure

7. Optimisation of end-of-life system

- Re-use of product
- Remanufacturing and/or refurbishing
- Recycling of materials
- Safer incineration
- Safer disposal of product remains



@ New concept development

- Dematerialisation
- Shared use of the product
- Integration of functions
- Functional optimisation of product (components)

C.

Circular Economy tools

Industrial symbiosis

[R. Frosch & N. Gallopoulos, 1989]

Circular Economy tools

SPECIFIC COURSES

1. Diagnose of prescribe a system state by modelling material and energy flows:

Material Flow Analysis (MFA)

2. Calculate an potential environmental impact of a system:

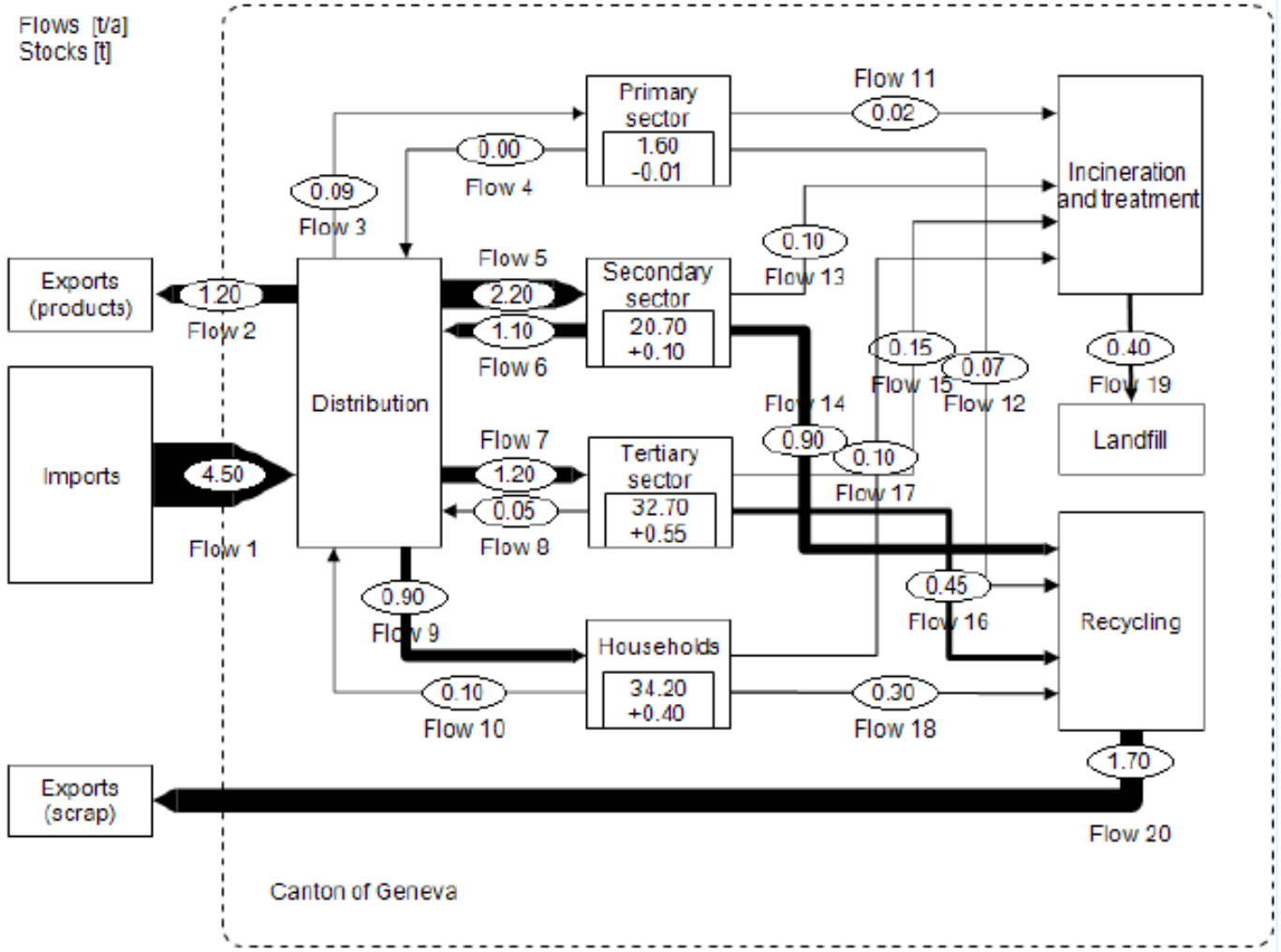
Life Cycle Assessment (LCA)

3. Monitor and improve the circularity of a product, company or industrial value chain:

Circularity indicators

Material Flow Analysis (MFA)

EXAMPLE OF COPPER ON THE CANTON OF GENEVA



[Suren Erkman]

Life Cycle Assessment (LCA)

EXAMPLE : ARTICIFIAL VS. NATURAL CHRISTMAS TREES

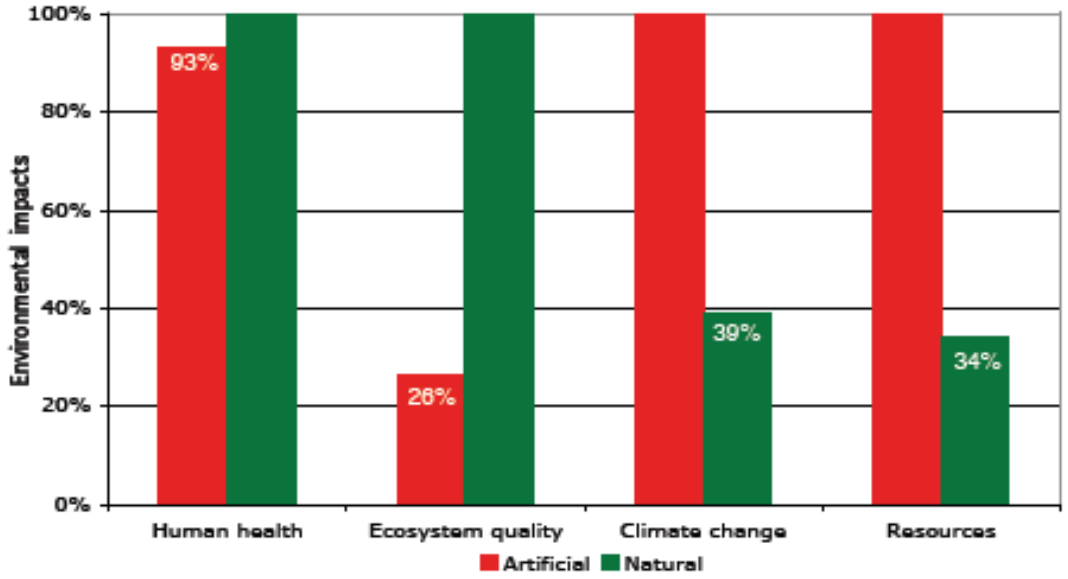


Figure D – LCA results comparing relative impacts for four damage categories comparing main life cycle stages of an artificial tree (red) and a natural tree (green) for one year using a modified IMPACT 2002+ method to include biogenic CO_2 emissions.

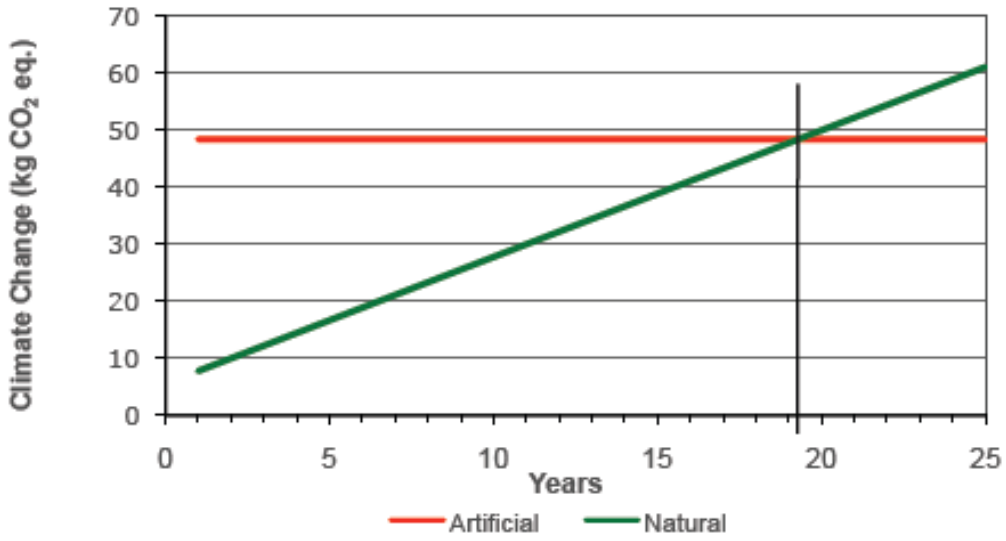
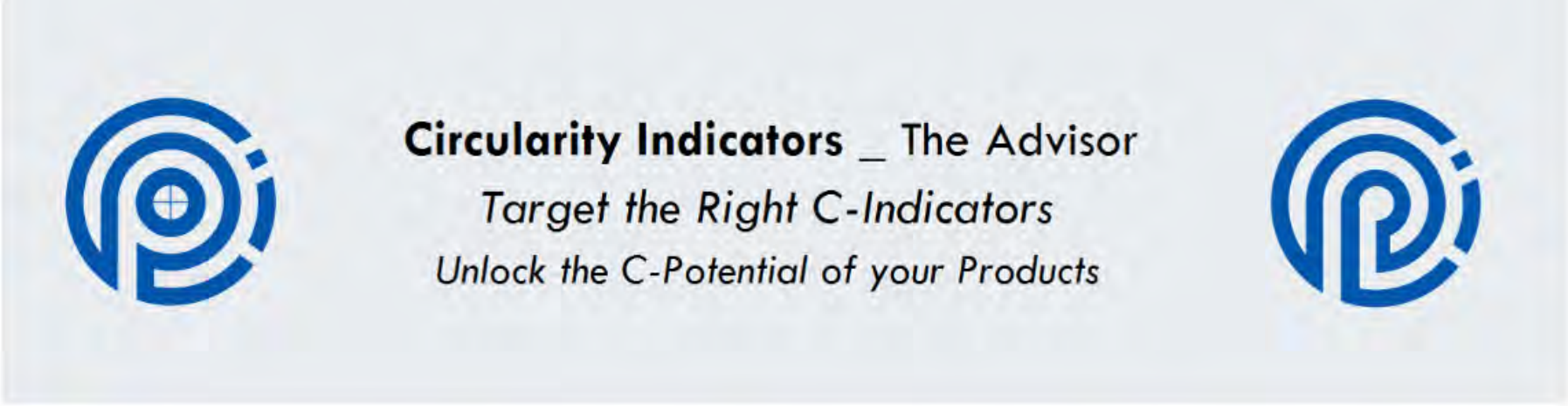


Figure E – The artificial tree can be reused multiple times. This reduces its impacts overtime relative to a natural tree bought every year. The threshold at which point the artificial tree become a better option for climate change impacts is after 20 years.

Circularity indicators



22/09/2022

Questions

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