

Life Cycle Analysis for concrete sleepers: methodology and implementation

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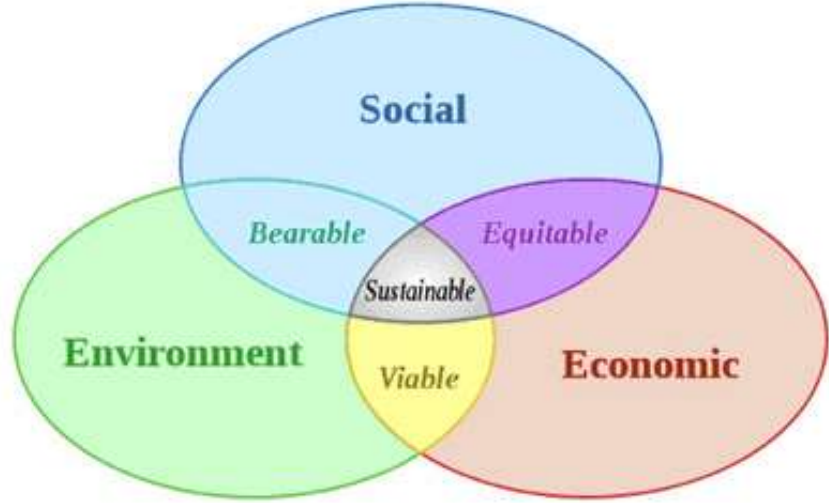
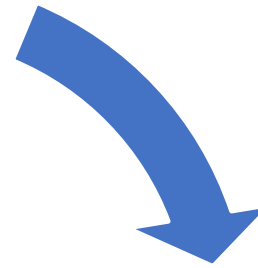
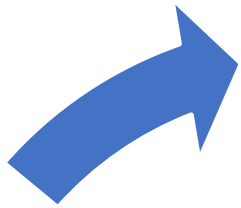
Sustainable development

Development that meets the needs of the present generation without compromising the ability of future generations to meet their needs



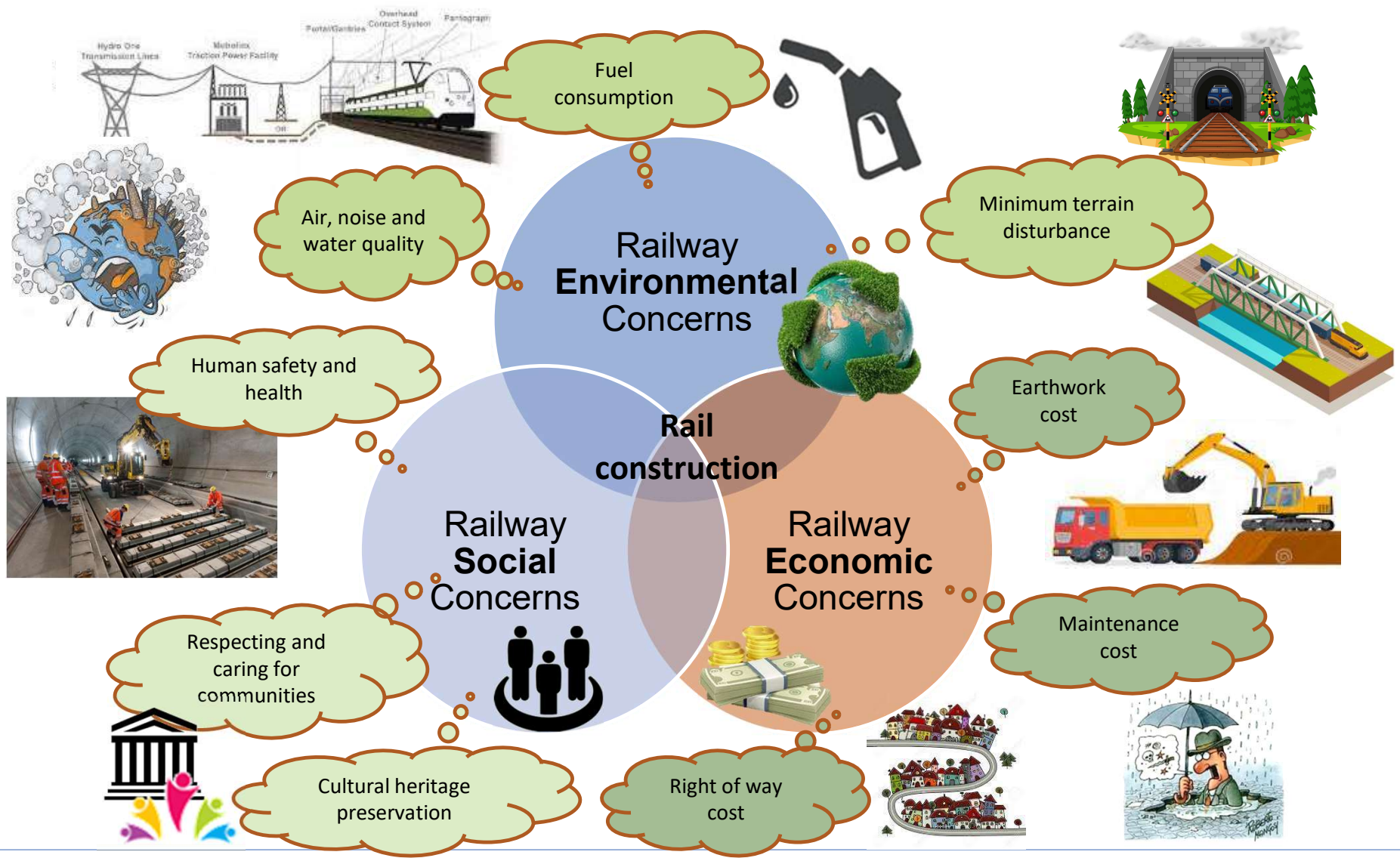
World Commission on Environment and Development (the Brundtland report)
report “Our Common Future” (1987)



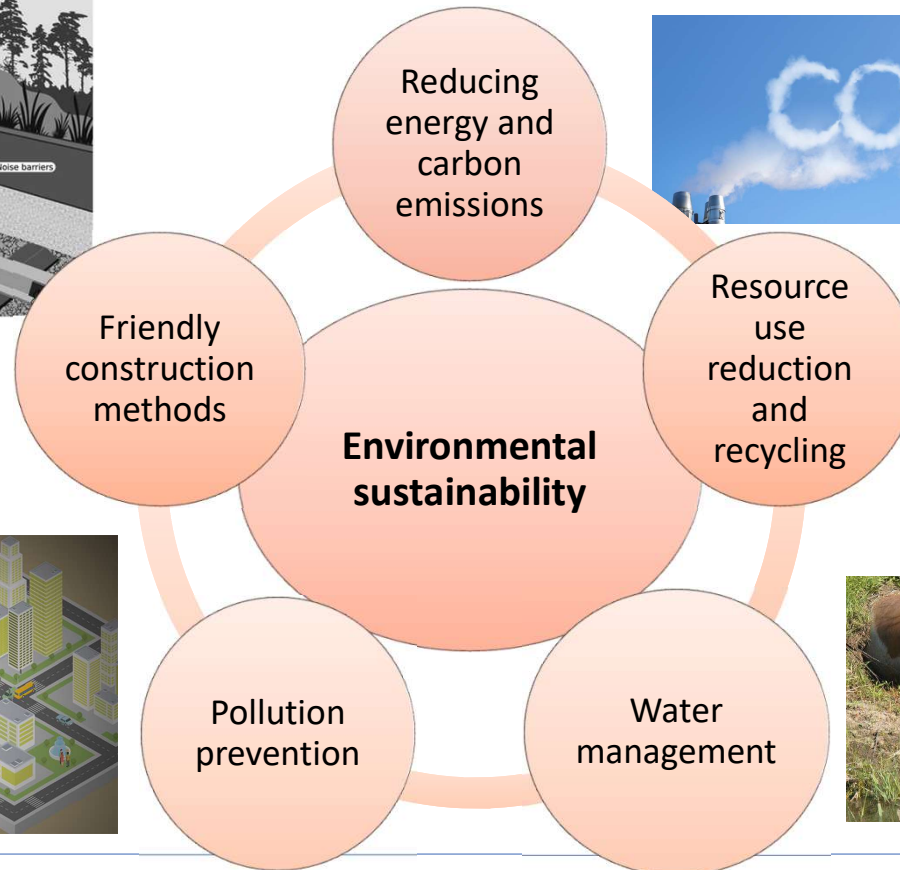
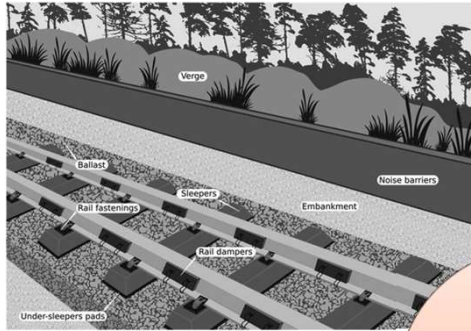


Rio Declaration on Environment and Development (1992)

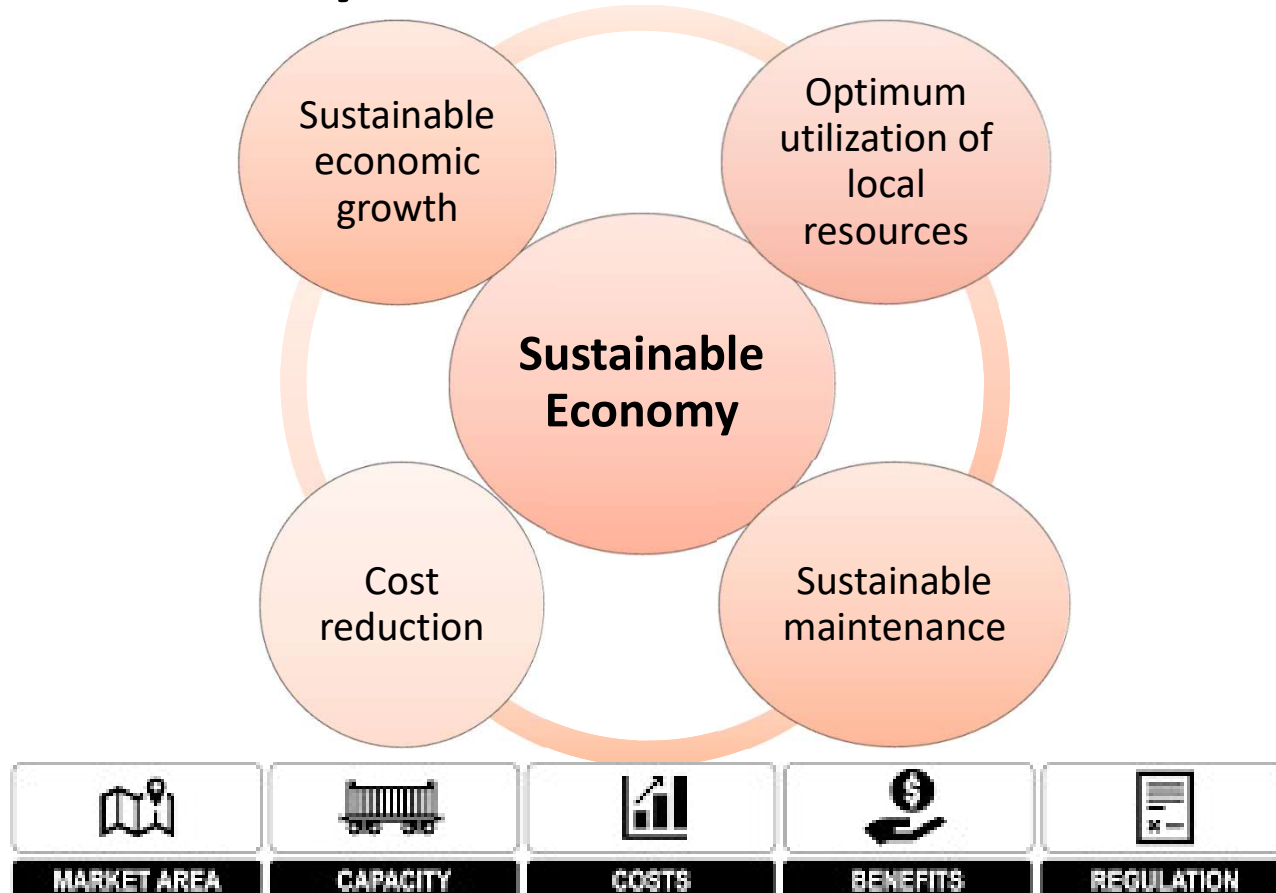




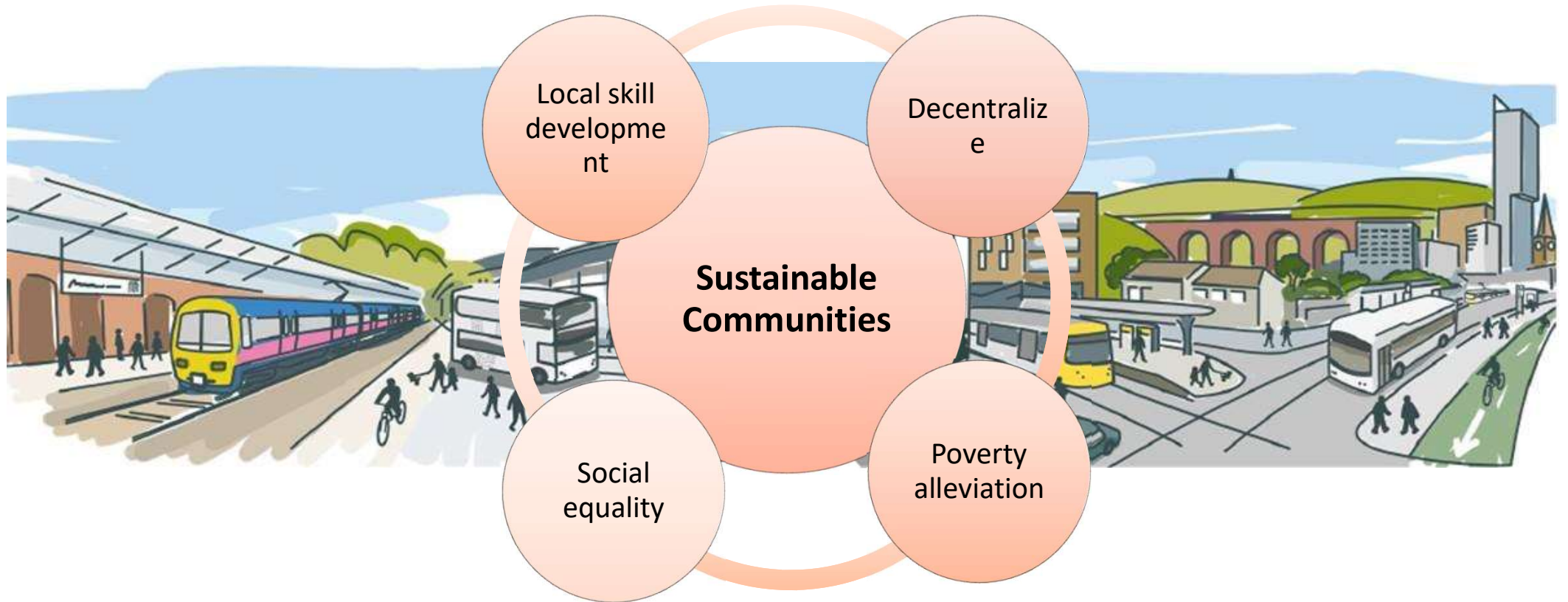
Railway environmental concerns



Railway economic concerns



Railway social concerns



European regulation towards sustainability

COM (2003) 302 Communication of European Commission

Life cycle assessment provides the best framework for assessing the potential environmental impacts of products currently available.

LCA is part of Integrated Product Policy strategy to reduce the environmental impacts from products throughout their life-cycle.

COM (2008) 400 Communication of European Commission

Public procurement can make an important contribution to sustainable consumption and production.



European regulation towards sustainability

COM (2020) 98 Communication of European Commission

The construction sector requires vast amounts of abiotic resources and it accounts for about 50% of all extracted material and is responsible for over 35% of the EU's total waste generation.





Italian background

Decree of Ministry of Ecological Transition 23/06/2022

provides minimum environmental criteria (in Italian, Criteri ambientali minimi CAM) to design and build construction works

D. Lgs. 31/03/2023, art. 57

confirms CAM are mandatory in all public construction projects





Italian background

CAM consists of mandatory or voluntary requirements such as:

- at least 5% by weight of concrete must contain secondary (i.e., recycled, recovered or by-product) raw materials,
- at least 70% of non-hazardous demolition waste must be prepared for re-use and recycling,
- at least 60% of permeable surfaces,
- designers with LCA experience,
- low-impacting earthmoving machines,
- low-distance raw materials.



Who needs an LCA? And why?



Product Development & Research & Development

Complying & Developing Products



Supply Chain Management & Procurement

Evaluating Suppliers



Marketing & Sales

Communicate Competitive Edge



Executive Level & Strategic Management

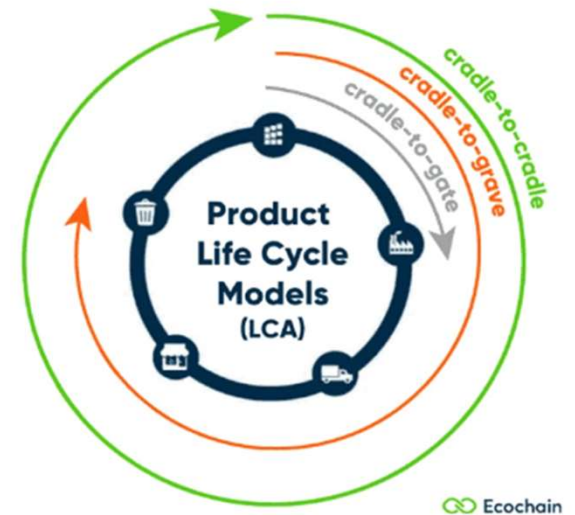
Avoid Risks, Lead Strategically



What is LCA?

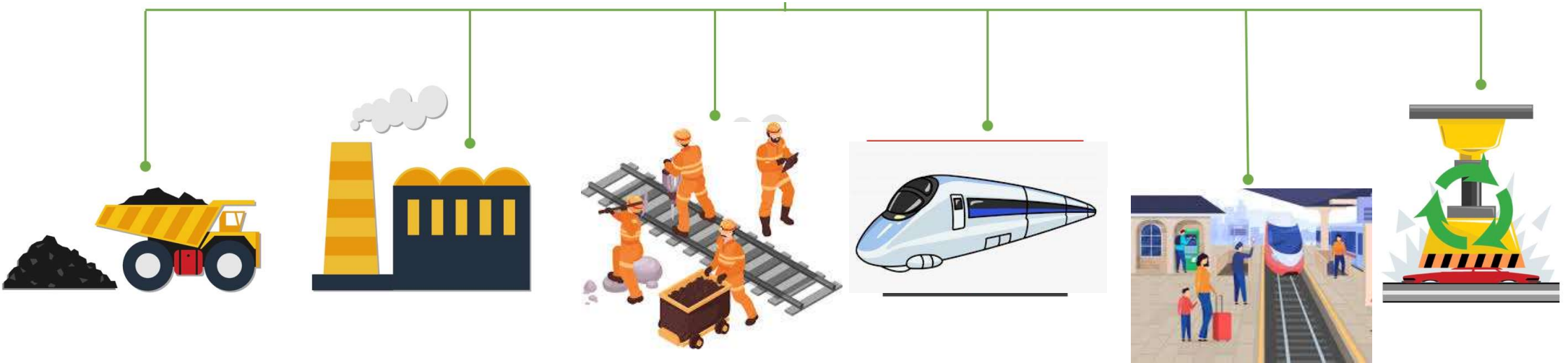
Life Cycle Assessment (LCA) is a standardized method to evaluate the environmental consequences of a product or activity across its entire life.

Possible Life Cycle Models:
from-cradle-to-gate
from-cradle-to-grave



How to do a LCA?

PCR (Product Category Rules - Regole di Categoria di Prodotto) provide category-specific guidance for estimating and reporting product life cycle environmental impacts when conducting the LCA.



Product category rules for building materials

SIST EN 15804:2012+A2:2019/AC:2021

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN
15804:2012+A2:2019/AC

August 2021

ICS 91.010.99

English version

Sustainability of construction works - Environmental product declarations -
Core rules for the product category of construction products

Contribution des ouvrages de construction au développement durable - Déclarations environnementales sur les produits - Règles régissant les catégories de produits de construction

Nachhaltigkeit von Bauwerken - Umweltproduktdeklarationen - Grundregeln für die Produktkategorie Bauprodukte

This corrigendum becomes effective on 18 August 2021 for incorporation in the official English version of the EN.

EN 15804:2019+A2 defines the setup of Environmental Product Declarations (EPD) in the construction industry. It provides core PCR for Type III environmental declarations for any construction product and service. The assessment of social and economic performances at the product level is not covered by this standard.



EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Ref. No.: EN 15804:2012+A2:2019/AC:2021 E



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ISO 14000 - Environmental Management Standards

ISO 14001	Certification of Environmental Management Systems
ISO 14010	Audit guidelines
ISO 14011	Audit methodology
ISO 14012	Qualification of auditors
ISO 14013-14015	Audit processes
ISO 14020-14025	Environmental labeling
ISO 14031-14032	Environmental performance evaluation
ISO 14040 / 14044	Life Cycle Assessment – General principles and practices
ISO 14050	Terms and Definitions
ISO 19011	Guide for management systems auditing



ISO 14001: Environmental Management Systems



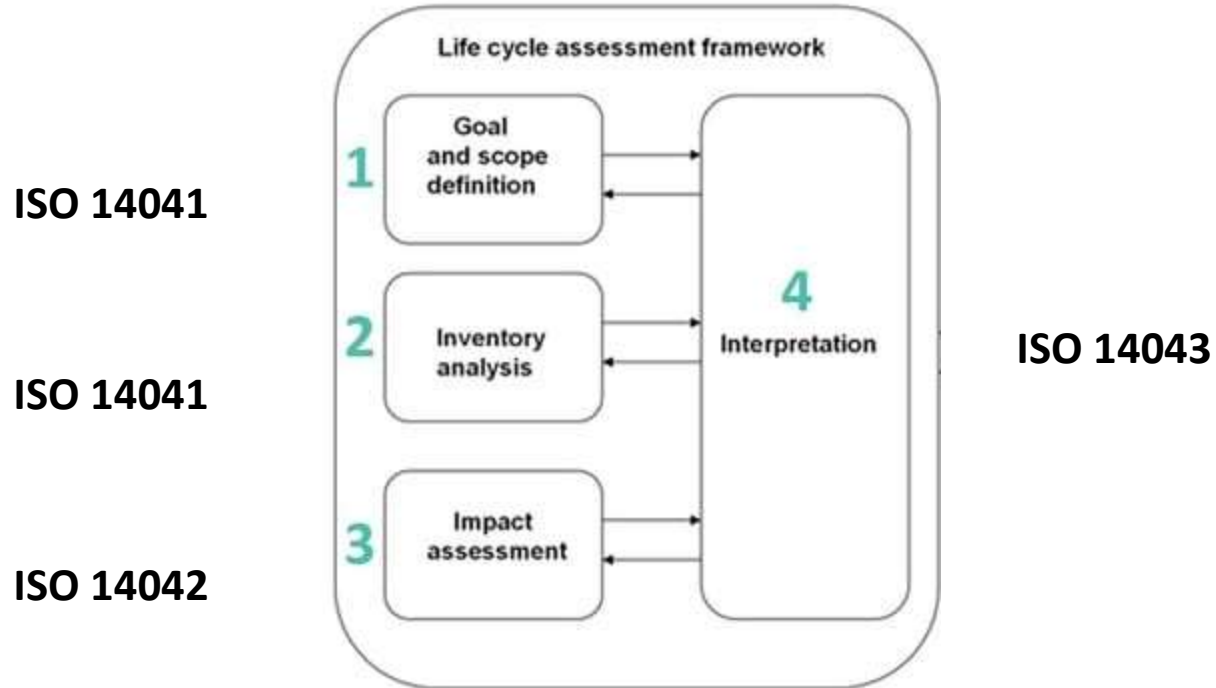
ISO 14040 / 14044: Life Cycle Assessment



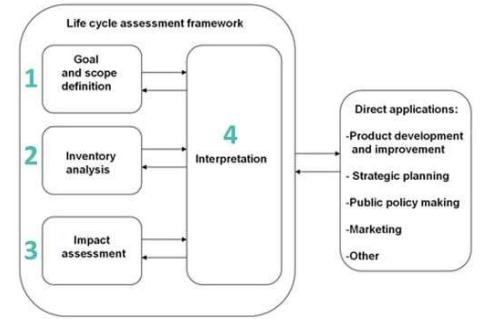
ISO 14020-14025: Environmental Labeling



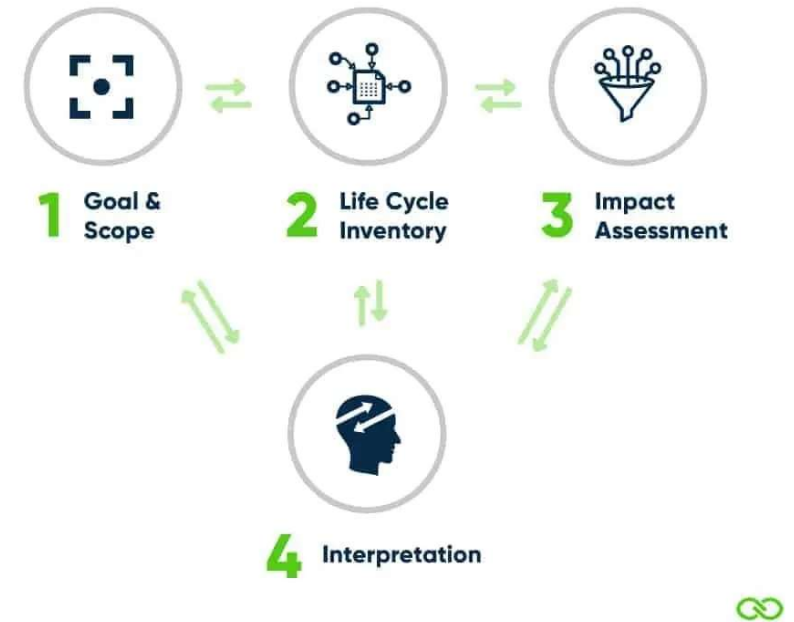
ISO 14041 / 14043: LCA framework



Four Phases of a Life Cycle Analysis



1. Definition of Goal and Scope
2. Inventory Analysis
3. Impact Assessment
4. Interpretation



Quick guide to Life Cycle Assessment (LCA)

WHAT'S THE ENVIRONMENTAL IMPACT OF MY PRODUCT / COMPANY / SERVICE?

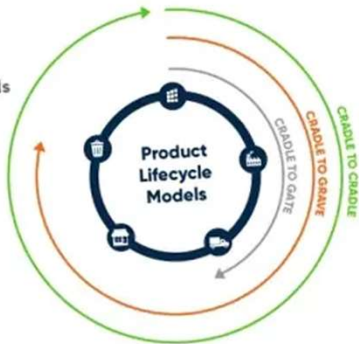


Why ask?

- Management**
Make sustainable decisions
- Product Development**
Develop sustainable products
- Sales & Marketing**
Prove sustainable claims
- Supply Chain**
Find better suppliers

What is the „Life Cycle“?

- Stages:**
- Raw Materials
 - Processing
 - Transport
 - Retail / Use
 - Waste



LCA is a framework standardized by ISO 14044 to measure this impact!
It's conducted in 4 stages:

1 Goal & Scope
WHAT DO WE WANT TO MEASURE?

- Define the product / company / service you want to measure
- What system do we measure in?
Which parts of the life cycle?
Which impact category (CO2, water,...)?
- What do we exclude?

You can't just compare one LCA to another. It's important to compare the goal & scope of each analysis! For better comparison, there are Product Category Rules (PCRs) that define how to analyze a certain product or industry.

2 Life Cycle Inventory
COLLECT AND STRUCTURE OUR DATA

What data do we need? In this stage, we collect all the inputs and processes that we want to measure. For example...

The raw materials and bill of materials
The energy we use and buy
Supplier data
... everything that goes into and flows out of the system we want to measure!

The easiest way to structure your data is in a flow- or tree-chart - from input, over processes, to outputs, and waste.

3 Impact Assessment
TRANSLATE OUR DATA TO IMPACTS

- We look at Life Cycle Databases (for example Ecoinvent) and scientific papers to define what the impact of our Life Cycle Inventory is.
- We sum up the impacts in category totals - for example, Global Warming Potential (CO2).

We translate everything to our total. Example: Our category is CO2. 1 kg of nitrogen equals 25 kg of CO2 according to norm EN15804.

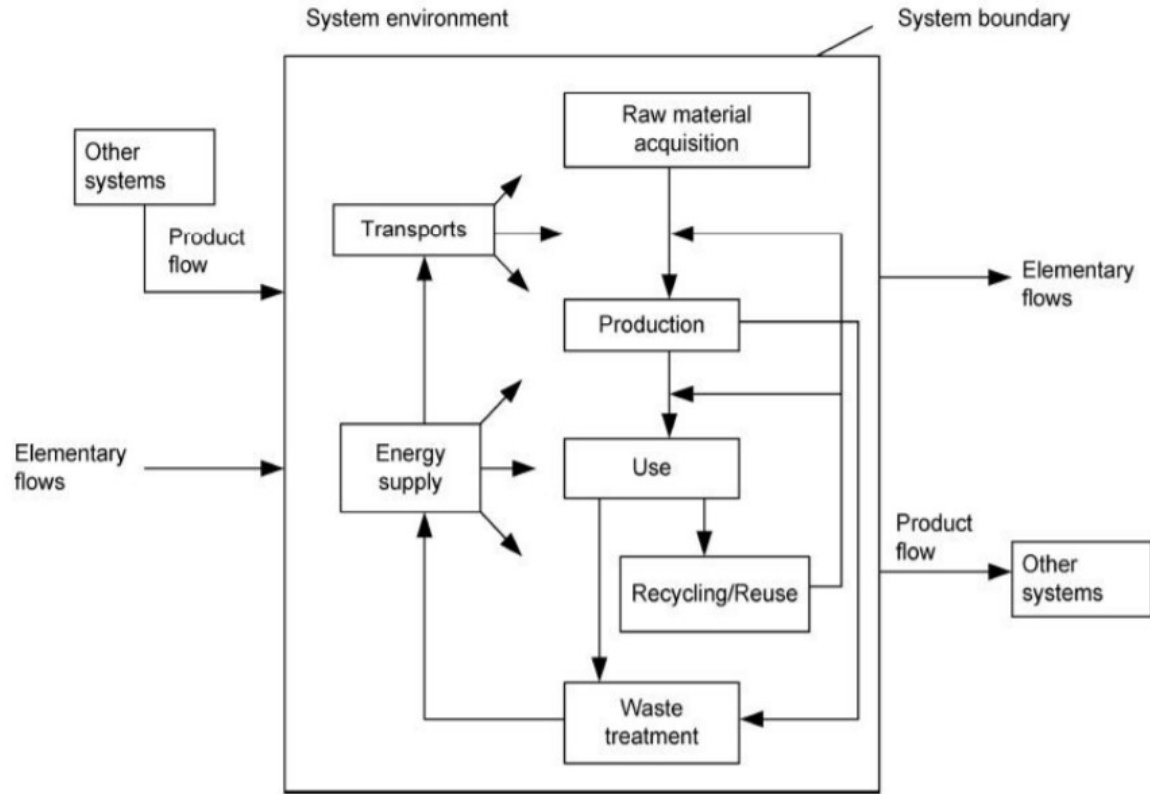
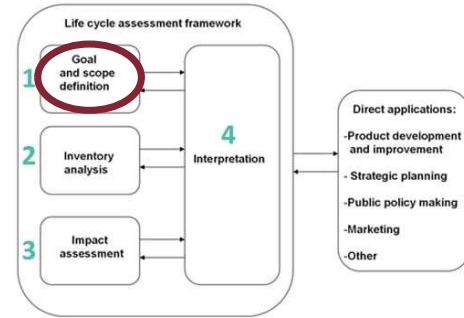
4 Interpretation
WHAT DOES ALL OF THIS MEAN?

- How high are our emissions?
- How do our products compare? Can we improve them?
- Can we improve our processes?
- What are the biggest levers for us?

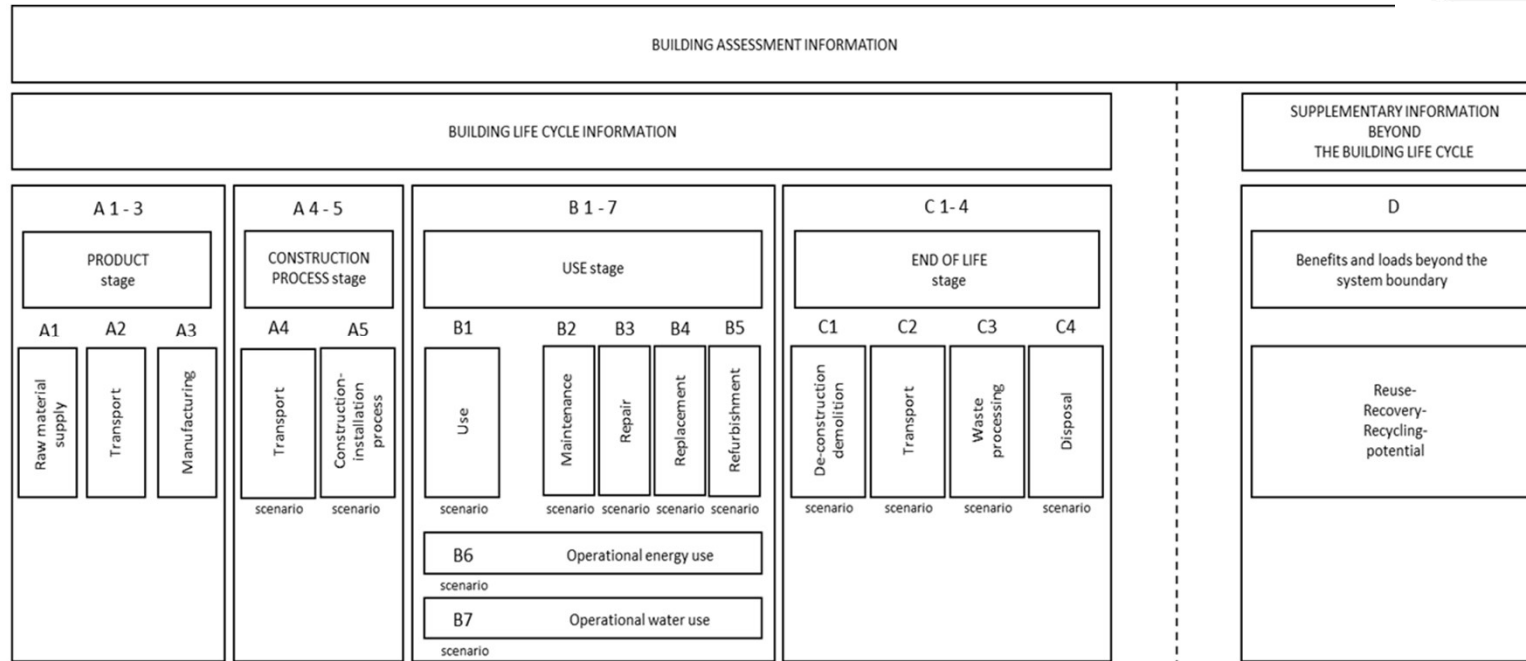
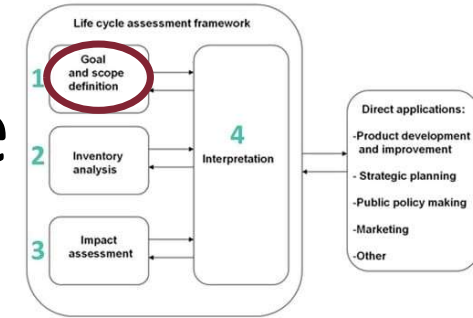
Based on the interpretation, it is common to go back to the analysis and re-assess certain aspects of it.

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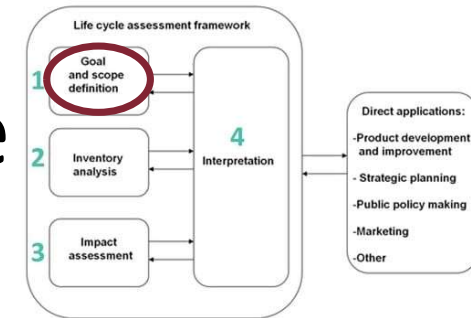
Phase 1: Definition of Goal and Scope



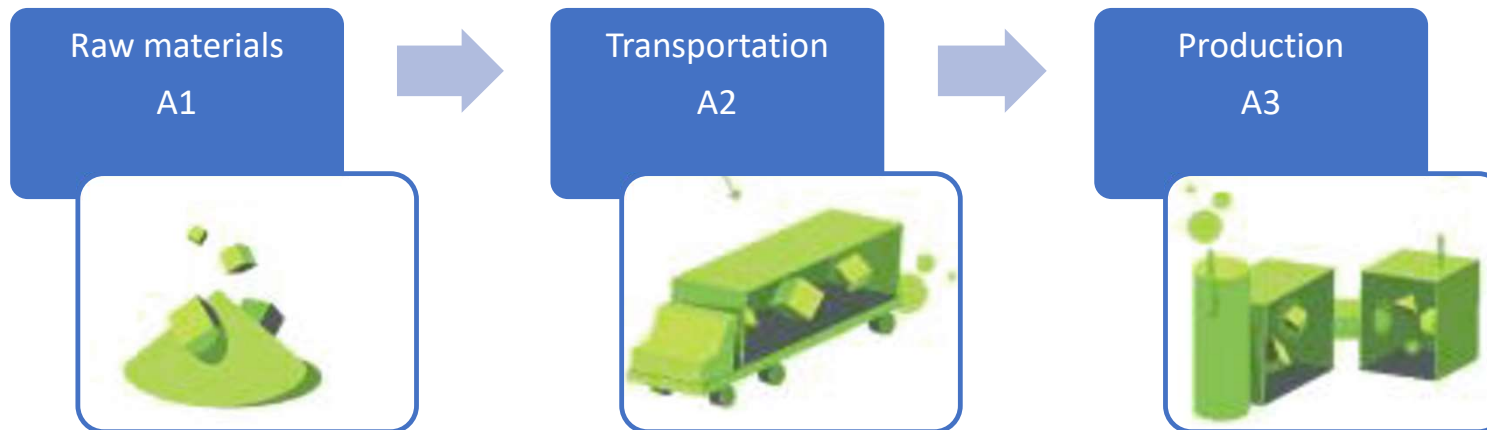
Phase 1: Definition of Goal and Scope



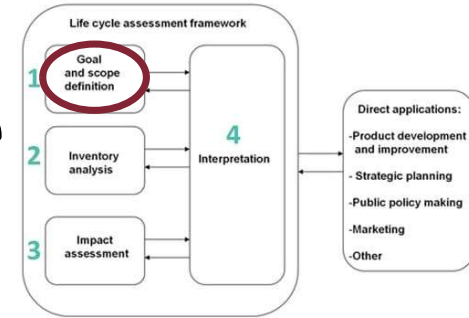
Phase 1: Definition of Goal and Scope



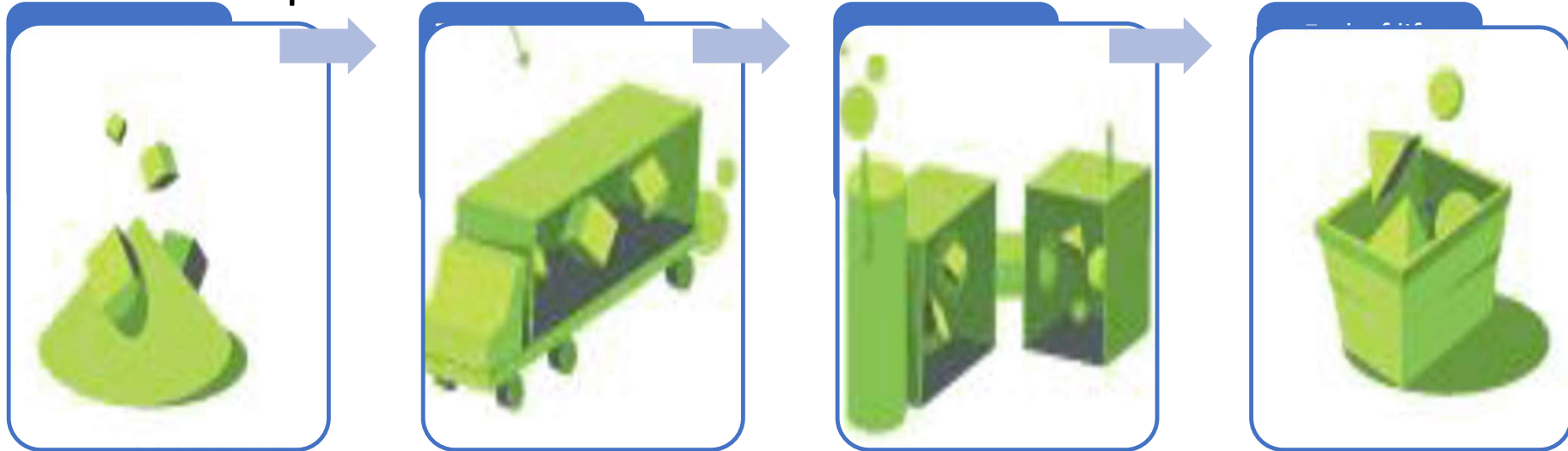
The simplest LCA model (i.e., «from cradle to gate») includes the modules A1 to A3 to have the product stage.



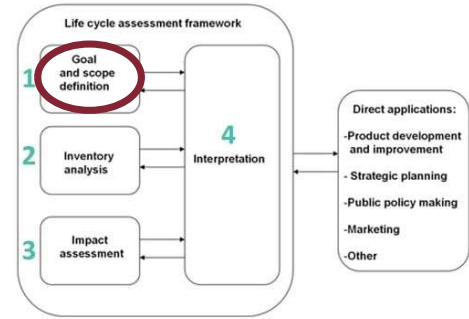
Phase 1: Definition of Goal and Scope



Further life cycle stages form the LCA “from cradle to gate with options”. It adds C1 to C4 and D modules about end-of-life stage to those about product stage.



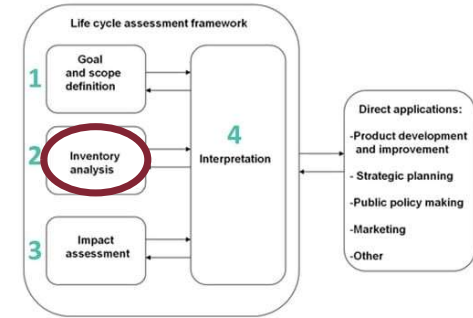
Phase 1: Definition of Goal and Scope



The life cycle of a product according to the system boundary leads to a “from cradle to grave” model. It includes the stages of production (modules A1 to A3), construction (modules A4-A5), use (modules B1-B7), and end-of-life (modules C1 to C4 and D).



Phase 2: Life Cycle Inventory (LCI)

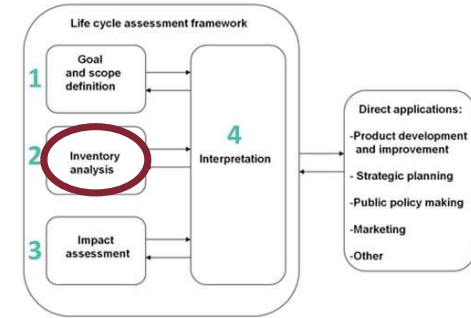


The LCI is the data collection phase of a Life Cycle Assessment. Input and output flows are collected to model them in the next phase – the Life Cycle Impact Assessment (LCIA).

Life Cycle Inventory (LCI) - Flow Model



Phase 2: Life Cycle Inventory (LCI)

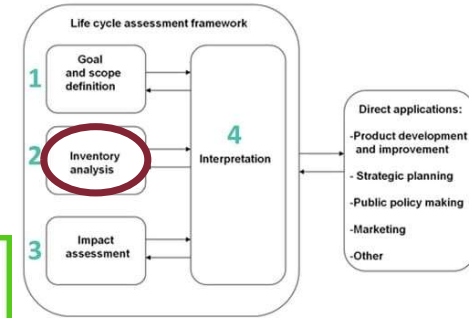


Raw materials and production phase (modules A1 to A3):
energy carriers, utilities, process emissions, production waste,
transport, raw materials, fuels ...





Use phase (modules B1 to B7):
transport to stores, average use & maintenance


End-of-life phase (modules C1 to C4 and D):
energy recovery, landfill, composting, or recycling


Phase 2: Life Cycle Inventory (LCI)



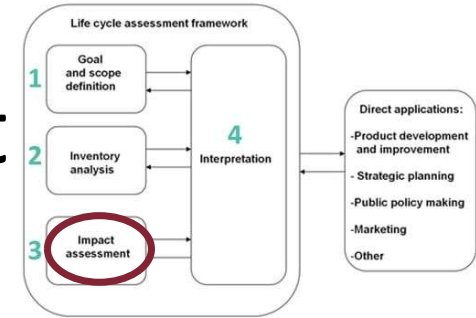
The data you need to make a product LCA

INPUT DATA:		RETRIEVE FROM:
1. COMPANY - ENERGY USAGE, EMISSIONS, AND WASTE.		FINANCE & SUSTAINABILITY DEPARTMENT.
2. PURCHASED AND USED RAW MATERIALS, TRANSPORT DISTANCES IN KM. (TYPE + QUANTITY)		PURCHASING DEPARTMENT & GOOGLE MAPS.
3. PER PROCESS: PRODUCT DISTRIBUTION, ENERGY USAGE, EMISSIONS. (TYPE + QUANTITY)		PROCESS ENGINEER, PRODUCT OWNER.
4. PRODUCTION COMPOSITION - BILL OF MATERIALS, UNIT(S) & WEIGHT PER PRODUCT, PRODUCTION QUANTITIES.		PRODUCT OWNER & PURCHASING DEPARTMENT.

 AIM TO WORK WITH AS MUCH PRIMARY DATA POSSIBLE (AUTHENTIC DATA FROM SUPPLIERS).

 Ecochain

Phase 3: Life Cycle Impact Assessment



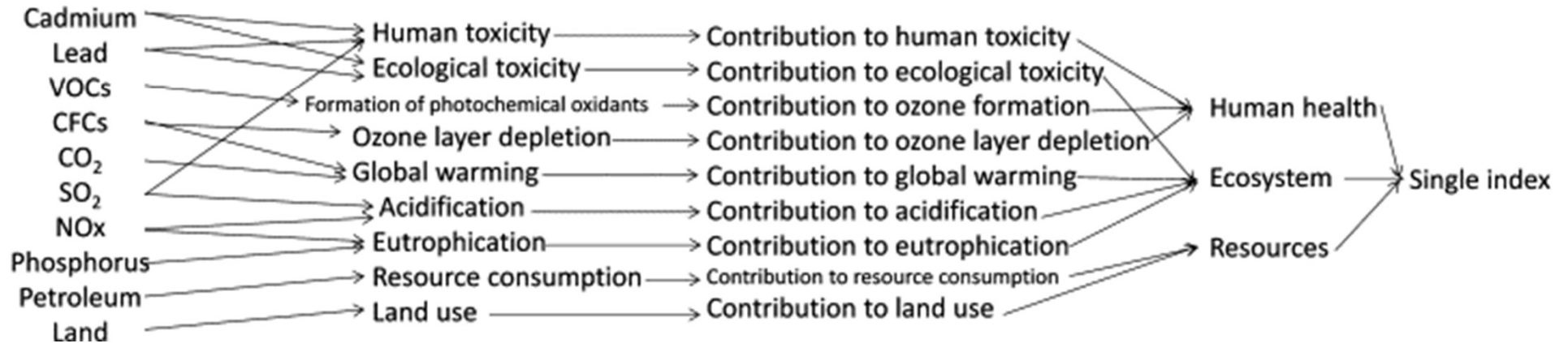
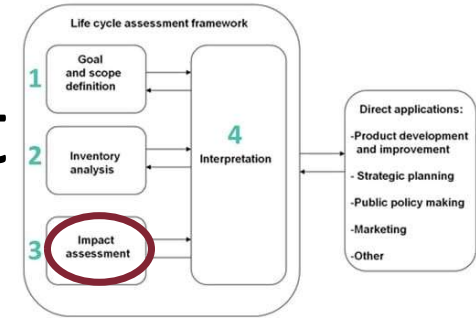
Task 1: Selection of indicators and models

- Environmental impact categories
- Resource use
- Waste type
- Output flows
- (Other environmental information)

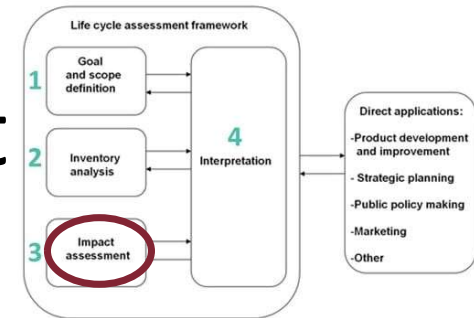
Task 2: Classification

Task 3: Impact Measurement

Phase 3: Life Cycle Impact Assessment



Phase 3: Life Cycle Impact Assessment

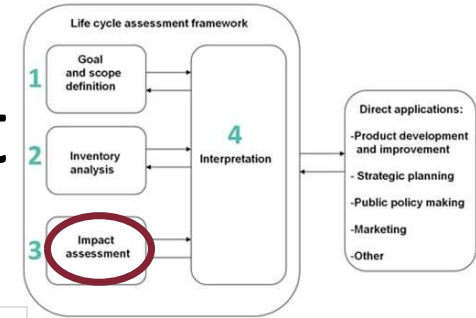


EN 15804:2019+A2 gives the characterization factors to compare the ability of different substances to cause the same environmental impact and assess it.

$$IC = \sum_x CF_{ic}(x) \cdot INV(x)$$

where IC is the Impact Category, $INV(x)$, and $CF_{ic}(x)$ is the characterization factor assigned to the substance x for IC calculation.

Phase 3: Life Cycle Impact Assessment



Impact category					
Climate change	kg CO2 eq				
Substances			CAS number	CF	Unit
Air	(unspecific)	Carbon dioxide	000124-38-9	1	kg
Air	(unspecific)	Carbon monoxide	000630-08-0	1,57	kg
Air	(unspecific)	Chloroform	000067-66-3	20	kg
Air	(unspecific)	Cis-perfluorodecalin	060433-11-6	8030	kg
Air	(unspecific)	Methane, fossil	000074-82-8	36,8	kg
Air	(unspecific)	Propane, 1-ethoxy-1,1,2,3,3,3-hexafluoro-	000380-34-7	28	kg
Air	(unspecific)	Propane, 1,1,1-trifluoro-, HFC-263fb	000421-07-8	92	kg
Air	(unspecific)	Propane, 1,1,1,2,2-pentafluoro-, HFC-245cb	001814-88-6	5300	kg
Air	(unspecific)	Propane, 1,1,1,2,2,3-hexafluoro-, HFC-236cb	000677-56-5	1440	kg
Air	(unspecific)	Propane, 1,1,1,2,2,3,3-heptafluoro-, HFC-227ca	002252-84-8	3080	kg
Air	(unspecific)	Propane, 1,1,1,2,2,3,3-heptafluoro-3-(1,2,2,2-tetrafluoro-	003330-15-2	7370	kg
Air	(unspecific)	Propane, 1,1,1,2,3-pentafluoro-, HFC-245eb	000431-31-2	352	kg
Air	(unspecific)	Propane, 1,1,1,2,3,3-hexafluoro-, HFC-236ea	000431-63-0	1600	kg
Air	(unspecific)	Propane, perfluoro-	000076-19-7	9880	kg
Air	(unspecific)	Propane, perfluorocyclo-		10200	kg
Air	(unspecific)	Propanol, 2,2,3,3-tetrafluoro-1-	000076-37-9	16	kg

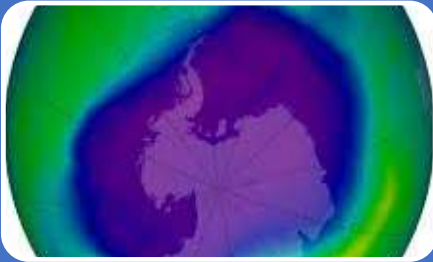
... and other 200 substances contribute to Climate change.

Environmental impact categories



Climate change - total, fossil, biogenic, and land use (kg CO₂-eq)

- Indicator of potential global warming due to emissions of greenhouse gases to the air



Ozone depletion (kg CFC-11-eq)

- Indicator of emissions to air that cause destruction of the stratospheric ozone layer



Acidification (kg mol H⁺)

- Indicator of the potential acidification of soils and water due to the release of gases such as nitrogen oxides and sulphur oxides

Environmental impact categories



Photochemical ozone formation (kg NMVOC-eq)

- Indicator of emissions of gases that affect the creation of photochemical ozone in the lower atmosphere (smog) catalysed by sunlight



Depletion of abiotic resources - minerals and metals (kg Sb-eq)

- Indicator of the depletion of natural non-fossil resources



Depletion of abiotic resources - fossil fuels (MJ)

- Depletion of abiotic resources – fossil fuels

Environmental impact categories



Human toxicity - cancer, non-cancer (CTUh)

- Impact on humans of toxic substances emitted to the environment



Eutrophication - freshwater, marine, and terrestrial (kg PO₄-eq, kg N-eq, and mol N-eq)

- Indicator of the enrichment of the ecosystem with nitrogen or phosphor-containing compounds



Eco-toxicity (freshwater) (CTUe)

- Impact on freshwater organisms of toxic substances emitted to the environment



Water use (m³ world eq. deprived)

- Indicator of the relative amount of water used, based on scarcity factors

Environmental impact categories



Land use (dimensionless)

- Measure of the changes in soil quality (Biotic production, Erosion resistance, Mechanical filtration)



Ionizing Radiation

Ionising radiation, human health (kBq U-235)

- Damage to human health and ecosystems linked to the emissions of radionuclides



Particulate matter emissions (Disease incidence)

- Indicator of the potential incidence of disease due to particulate matter emissions

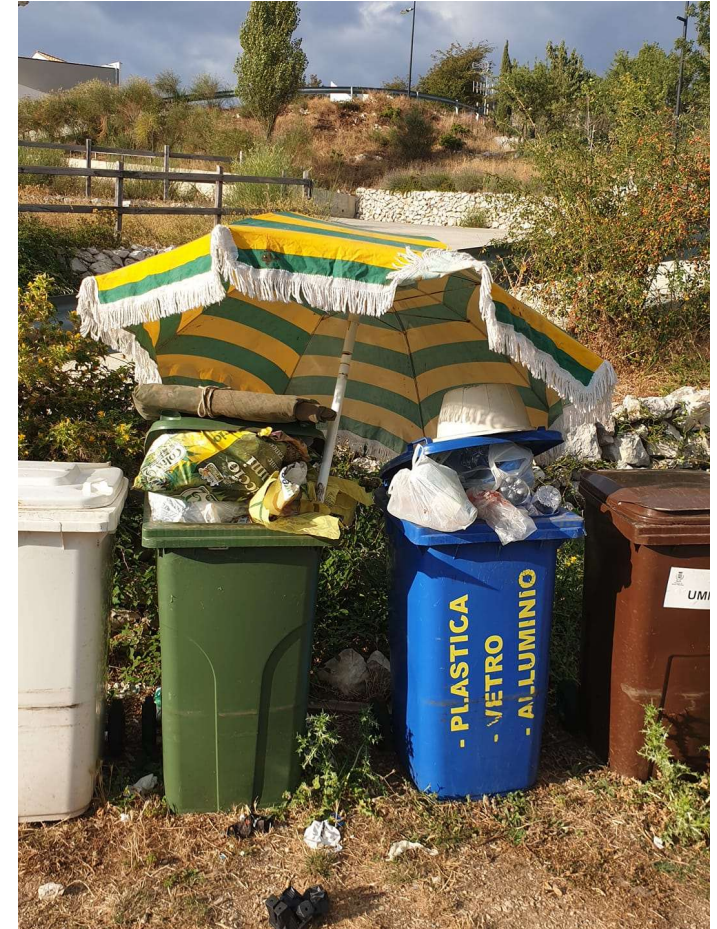
Resource use indicators

Impact category	Unit	Description
Primary renewable energy (materials)	MJ	Use of renewable primary energy resources as raw materials
Primary renewable energy (energy)	MJ	Use of renewable primary energy, excluding renewable primary energy resources used as raw materials
Primary renewable energy (total)	MJ	Sum of the two values above
Primary non-renewable energy (materials)	MJ	Use of non-renewable primary energy resources as raw materials
Primary non-renewable energy (energy)	MJ	Use of non-renewable primary energy, excluding renewable primary energy resources used as raw materials
Primary non-renewable energy (total)	MJ	Sum of the two values above
Use of freshwater	m ³	Freshwater use in absolute values
Use of renewable secondary fuels	MJ	Renewable fuel recovered from previous use or from waste which substitutes primary fuels
Use of non-renewable secondary fuels	MJ	Non-renewable fuel recovered from previous use or from waste which substitutes primary fuels



Waste indicators

Indicator	Unit	Description
Hazardous waste disposed	kg	Hazardous waste has a certain degree of toxicity that necessitates special treatment
Non-hazardous waste disposed	kg	Non-hazardous waste is non-toxic and similar to household waste. It consists of inert waste and ordinary household waste
Radioactive waste disposed	kg	Radioactive waste mainly originates from nuclear energy reactors

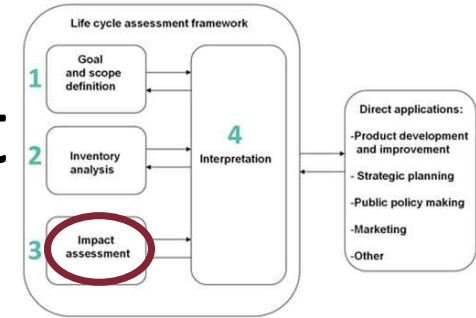


Output flows indicators

Indicator	Unit	Description
Components for re-use	kg	Material or components leaving the modelled system boundary which is destined for reuse
Materials for recycling	kg	Material leaving the modelled system boundary which is destined for recycling
Materials for energy recovery	kg	Material leaving the modelled system boundary which is destined for use in power stations using secondary fuels (minimum energy efficiency 60% or 65% for installations opened after 2008)
Energy production	MJ	Energy exported from waste incineration and landfill



Phase 3: Life Cycle Impact Assessment



The software SimaPro can do LCIA according to the method defined by EN 15804:2019+A2 or other methodologies recognized at international level using data from environmental databases as Ecoinvent 3.9.



Metodo
EPD AITEC2014 EN15804:2014_CementiRossi V1.00

Prodotto	Quantità fisica	Unità di misura	Progetto	Commento
CLINKER_Piacenza	1	ton		

Libreria attuale Suffisso

Sostituzione libreria Suffisso

Cambi

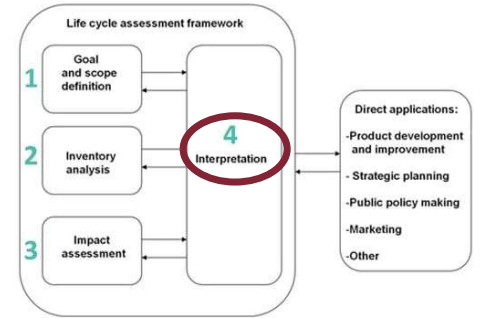
- Inventario per sottocompartimento
- Esclude processi di infrastrutture
- Esclude le emissioni di lungo termine

Criterio di fermata Monte Carlo

- Numero fisso di esecuzioni 1000
- Usa fattore di stop 0,005 Valore Risultato caratterizzato (Global warming (GWP 100))
- Valore 'seed' 0

Aiuto Calcola

Phase 4: Interpretation of LCA



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