Biocircularcities Trilogy – Ep. 1: Supporting local players with the transition to circular bioeconomy, and lifting the current barriers

BIO
CIRCULAR
CITIES

The environmental and economic impact of circular bioeconomy

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Bio-based Industries Consortium

Horizon 2020
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BBI JU

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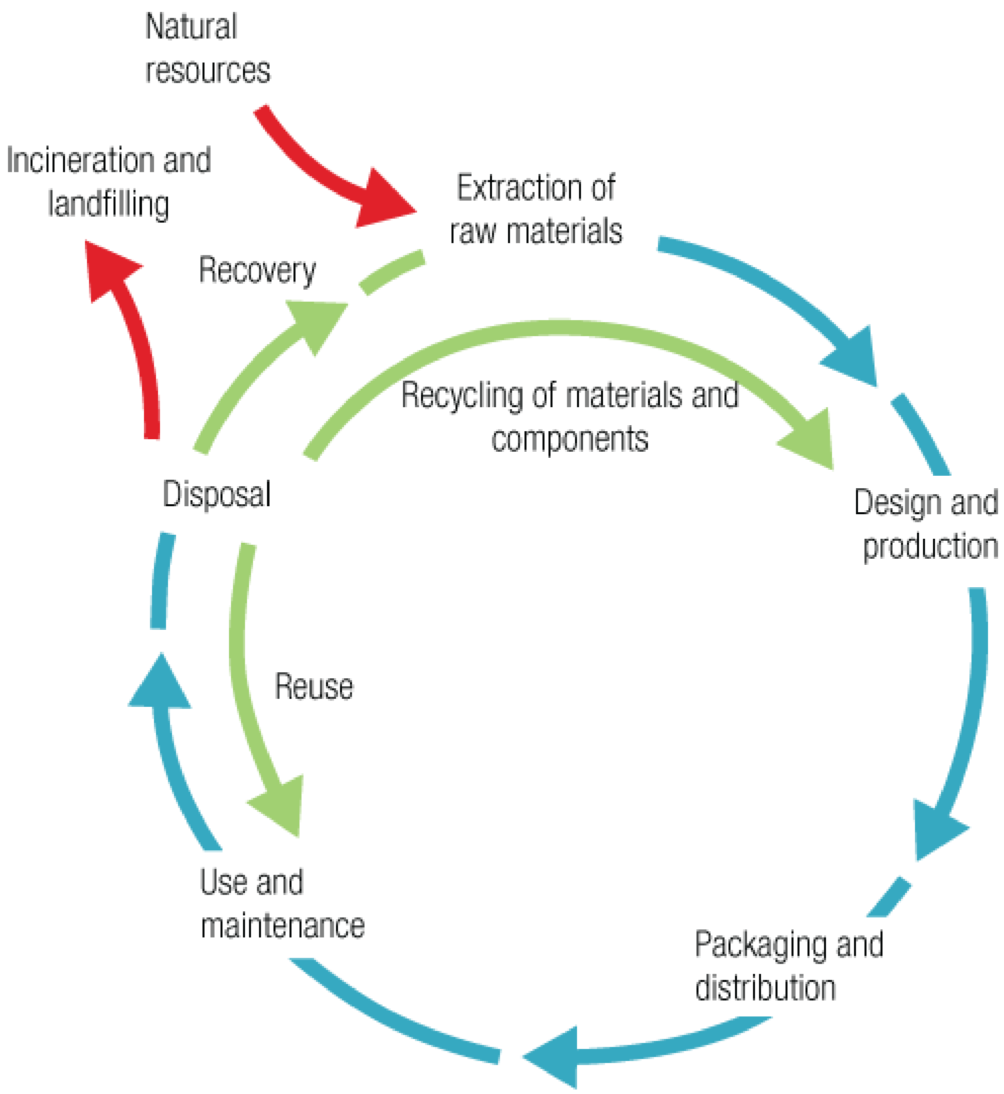
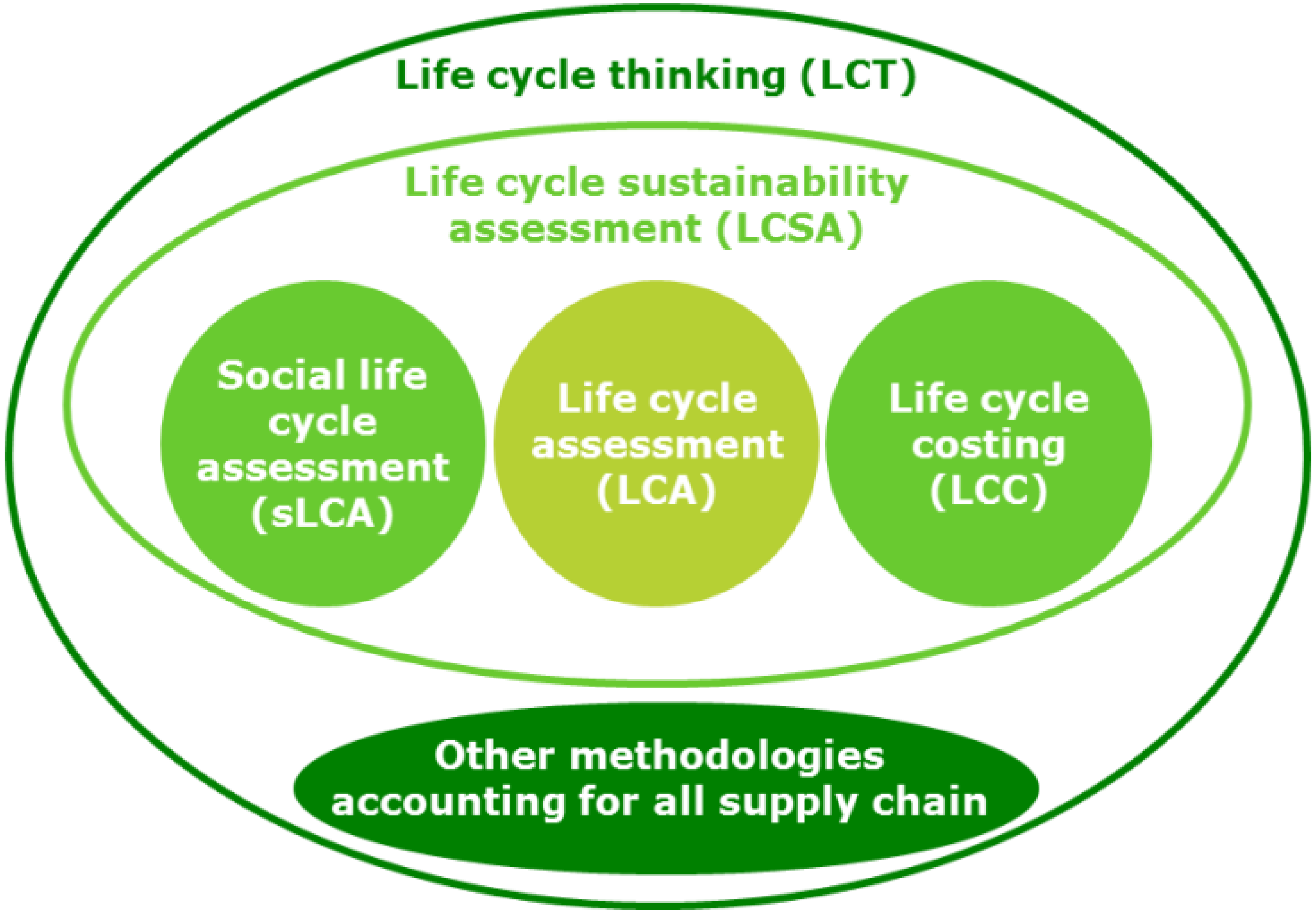
LIFE CYCLE THINKING (LCT)



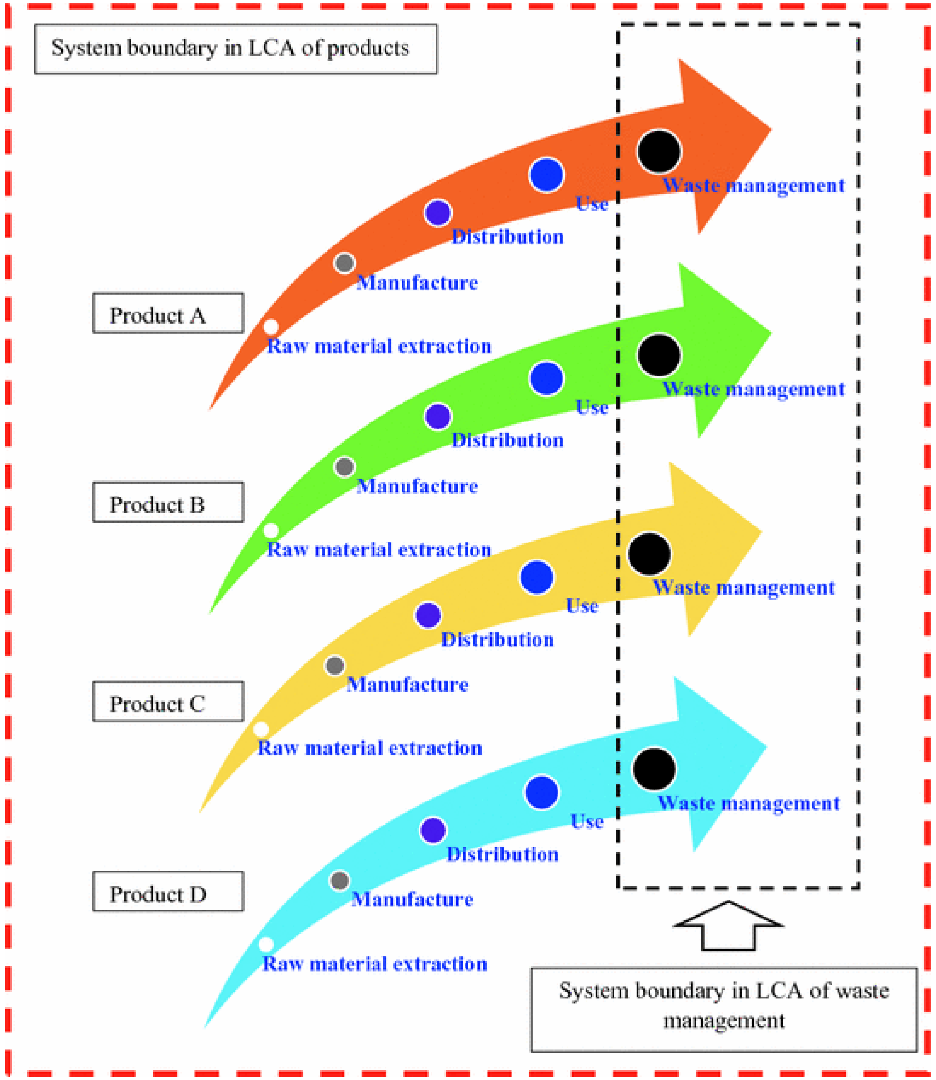
- PRE-PRODUCTION (procurement of raw materials)
- PRODUCTION (transformation of materials, assembly and finish)
- DISTRIBUTION (logistics, sales and packaging)
- USE AND CONSUMPTION (including maintenance)
- END OF LIFE (Reuse, Recycle, Recovery, Disposal)

THE METHODOLOGIES



Source: Sala S., Reale F., Cristobal-Garcia J., Marelli L., Pant R. (2016), Life cycle assessment for the impact assessment of policies, EUR 28380 EN; doi:10.2788/318544

Application of LCT to waste management



Source: Khoshnevisan et al (2018). In: Tabatabaei M., Ghanavati H. (eds) Biogas. Biofuel and Biorefinery Technologies, vol 6. Springer, Cham

- **WASTE COLLECTION**
  including containers, bins, bags
- **WASTE TRANSPORTATION**
  including transport to intermediate and treatment facilities
- **RECYCLING and RECOVERY PROCESSES**
  including material and energy input and output flows related to the treatment and the virgin material production displaced
- **DISPOSAL of RESIDUES**
  including the disposal of final fractions to landfill and the related emissions

LIFE CYCLE ASSESSMENT (LCA)

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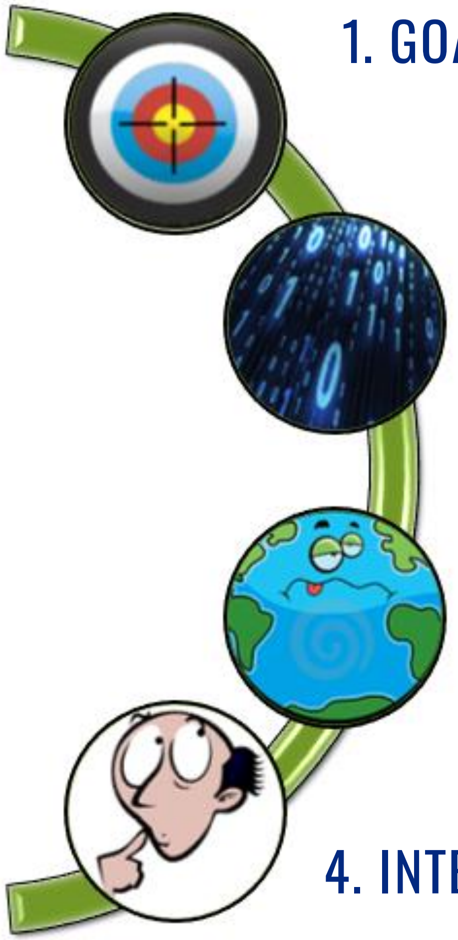
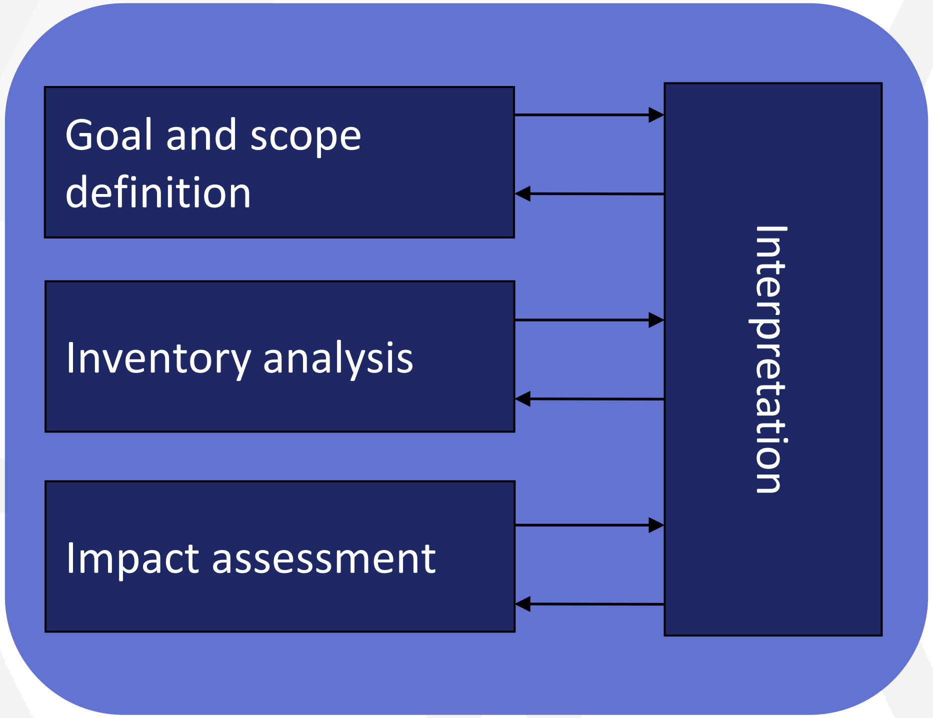


1. GOAL AND SCOPE DEFINITION

2. INVENTORY ANALYSIS - LCI

3. IMPACT ASSESSMENT - LCIA

4. INTERPRETATION

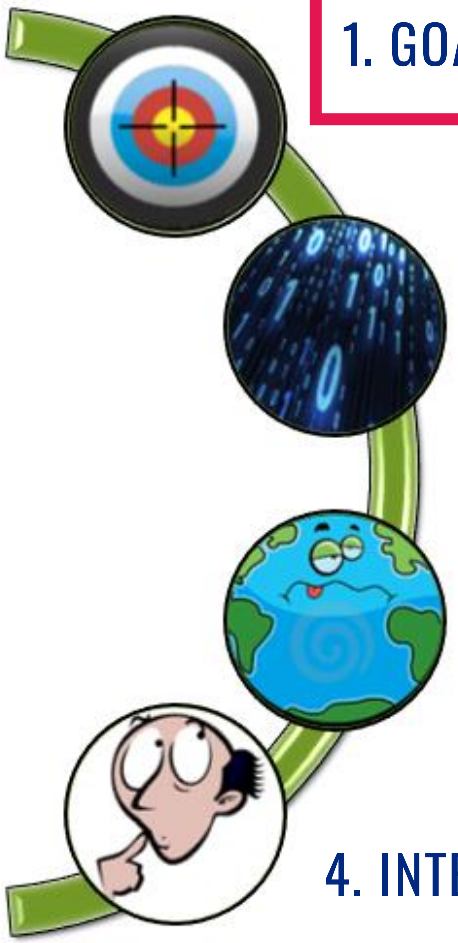


ISO International Organization for Standardization

ISO 14040:2006
Environmental management — Life cycle assessment — Principles and framework

ISO 14044:2006
Environmental management — Life cycle assessment — Requirements and guidelines

GOAL AND SCOPE DEFINITION



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4. INTERPRETATION

Goal and Scope definition

It is important to establish what purpose the model is to serve, what one wishes to study, what depth and degree of accuracy are required

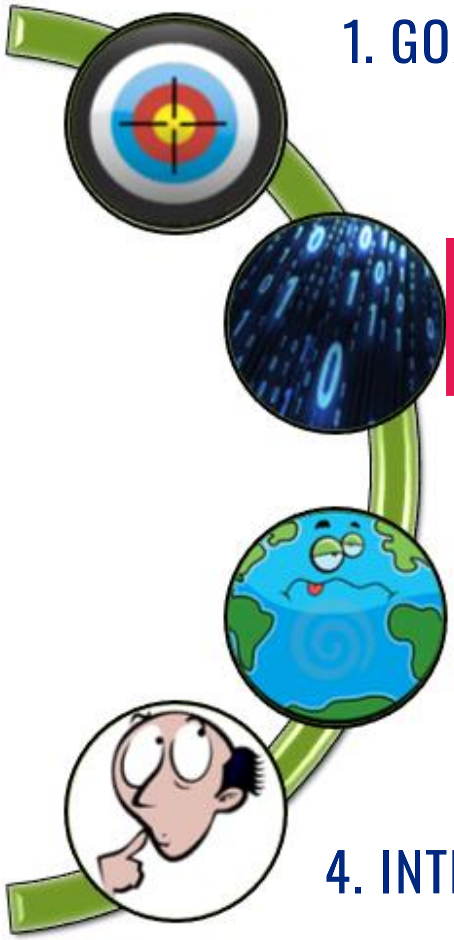
Functional Unit

FU is a quantified description of the function of a product that serves as the reference basis for all calculations regarding impact assessment.

System Boundaries

Physical, geographical, temporal

INVENTORY ANALYSIS (LCI)



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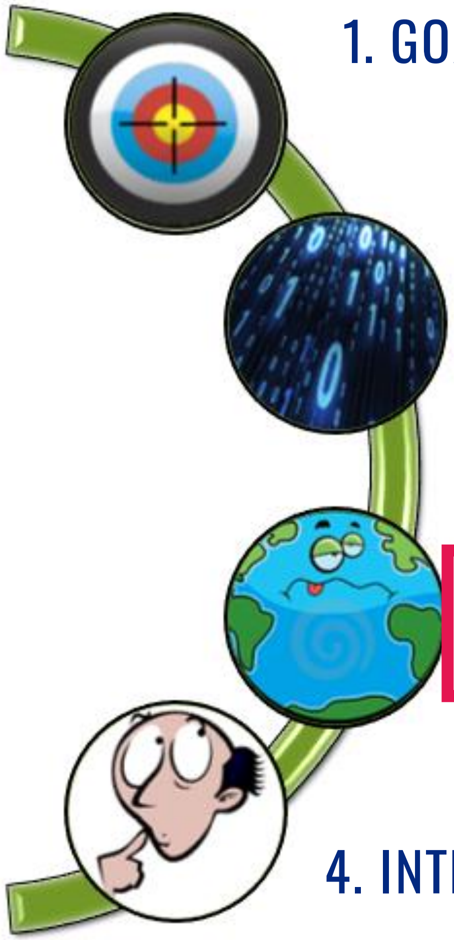
PRIMARY DATA

Data directly collected on field by the investigator, with and without the collaboration of process operators

SECONDARY DATA

Data representative of the process/sector dynamics, collected from literature or databases

LIFE CYCLE IMPACT ASSESSMENT (LCIA)



1. GOAL AND SCOPE DEFINITION
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4. INTERPRETATION

OpenSource software

OpenLCA

Quantis SUITE 2.0

Commercial software

GaBi

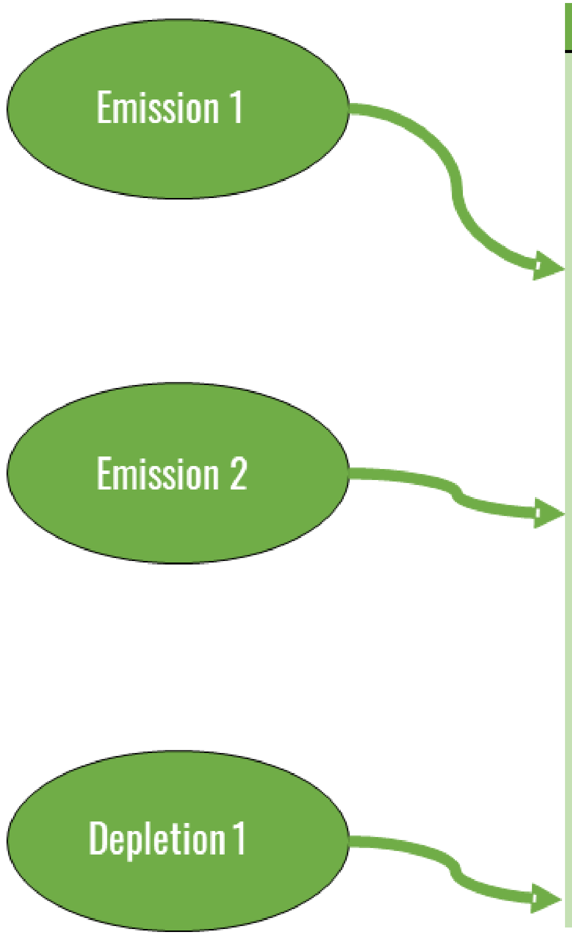
SimaPro

Umberto LCA+

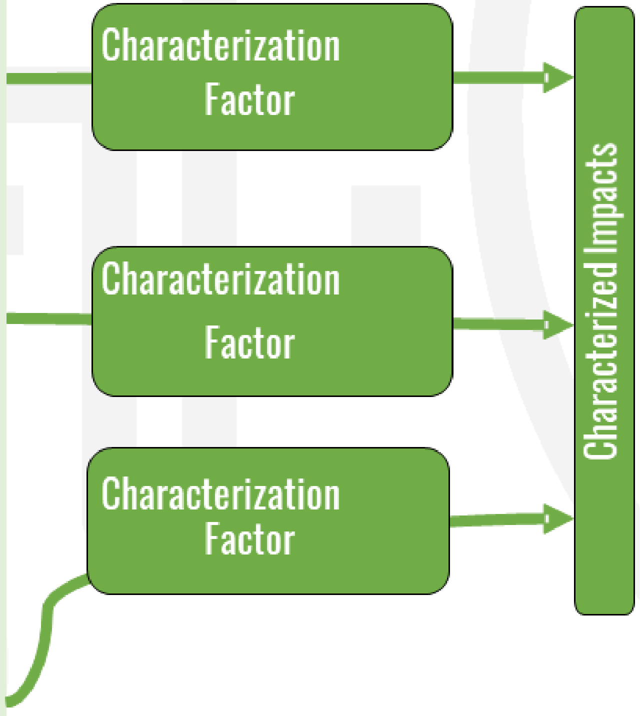
EIME

TEAM

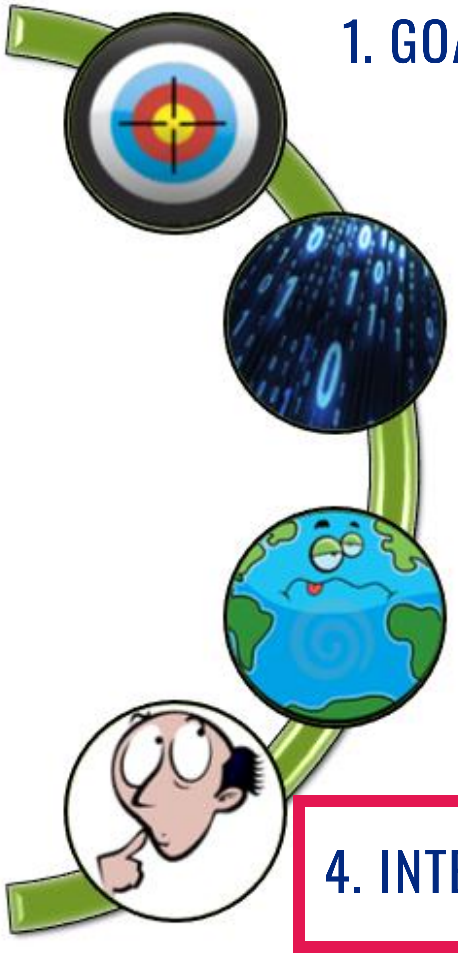
LIFE CYCLE IMPACT ASSESSMENT (LCIA)



Impact Category	Unit
Fine particulate matter formation potential	kg $PM_{2.5}$ eq
Fossil resource scarcity potential	kg oil eq
Freshwater ecotoxicity potential	kg 1,4-DCB
Freshwater eutrophication potential	kg P eq
Global warming potential	kg CO_2 eq
Human carcinogenic toxicity potential	kg 1,4-DCB
Human non-carcinogenic toxicity potential	kg 1,4-DCB
Ionizing radiation potential	kBq Co-60 eq
Land use potential	m^2a crop eq
Marine ecotoxicity potential	kg 1,4-DCB
Marine eutrophication potential	kg N eq
Mineral resource scarcity potential	kg Cu eq
Ozone formation, Human health potential	kg NO_x eq
Ozone formation, Terrestrial ecosystems potential	kg NO_x eq
Stratospheric ozone depletion potential	kg CFC11 eq
Terrestrial acidification potential	kg SO_2 eq
Terrestrial ecotoxicity potential	kg 1,4-DCB
Water consumption potential	m^3



INTERPRETATION



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4. INTERPRETATION

INTERPRETATION

Once the system has been analysed, this step aims at verifying if results are consistent with the goal and scope and if the procedure fits the ISO standards. Then improvements are suggested to minimize the environmental load.

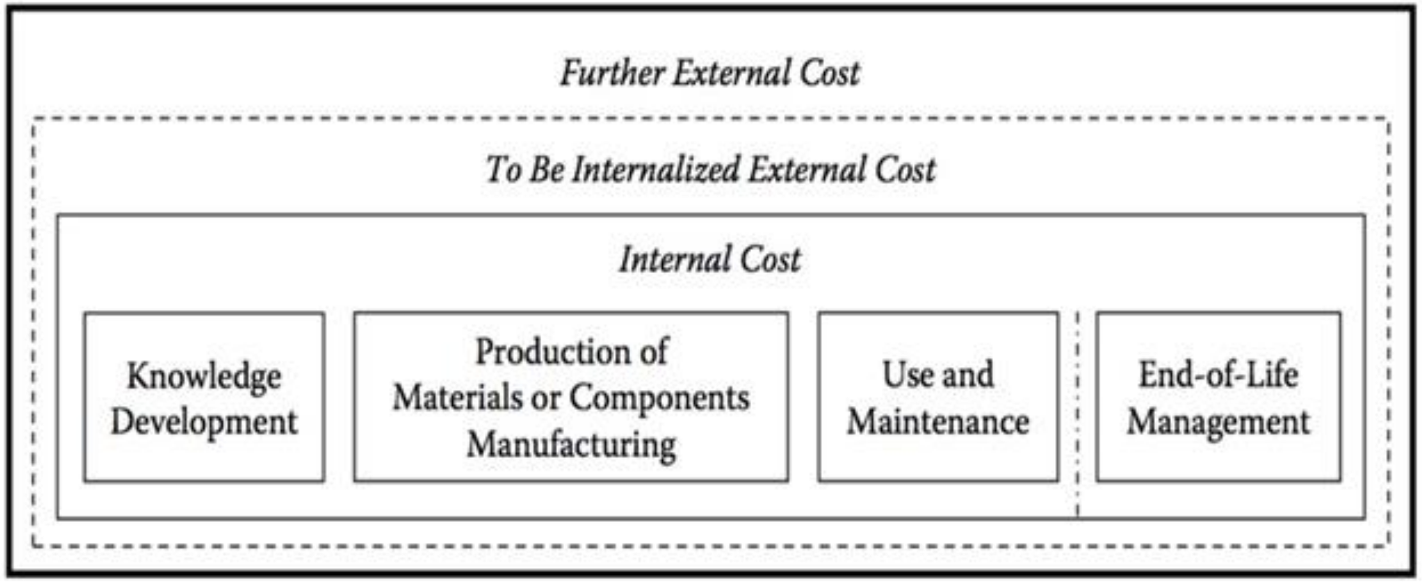
RECOMMENDATIONS

The results can be translated into recommendations to drive decision-making process in minimizing impacts resulting from products or services which would potentially affect the environment and humans and in supporting the local development .

Life Cycle Costing (LCC) analysis

Life Cycle Costing (LCC) is applied as an assessment tool to estimate the entire cost of the system under investigation, during its whole life cycle.

In this study the Environmental LCC (eLCC) has been performed, including both internal and external costs (also known as externalities or environmental costs).



— Conventional LCC: Assessment of internal costs, mostly without EoL costs; no LCA
--- Environmental LCC: Additional assessment of external costs anticipated to be internalized in the decision relevant future; plus LCA in societal = natural boundaries
— Societal LCC: Additional assessment of further external costs

Selected method:
Environmental Priority Strategies (EPS) 2015dx

Safeguard subjects/ Areas of protection
Abiotic Resources
Access to Water
Bio-Diversity
Ecosystem Services
Human Health

1 ELU (Environmental Load Unit) = 1 €

LCA and LCC: Benefits

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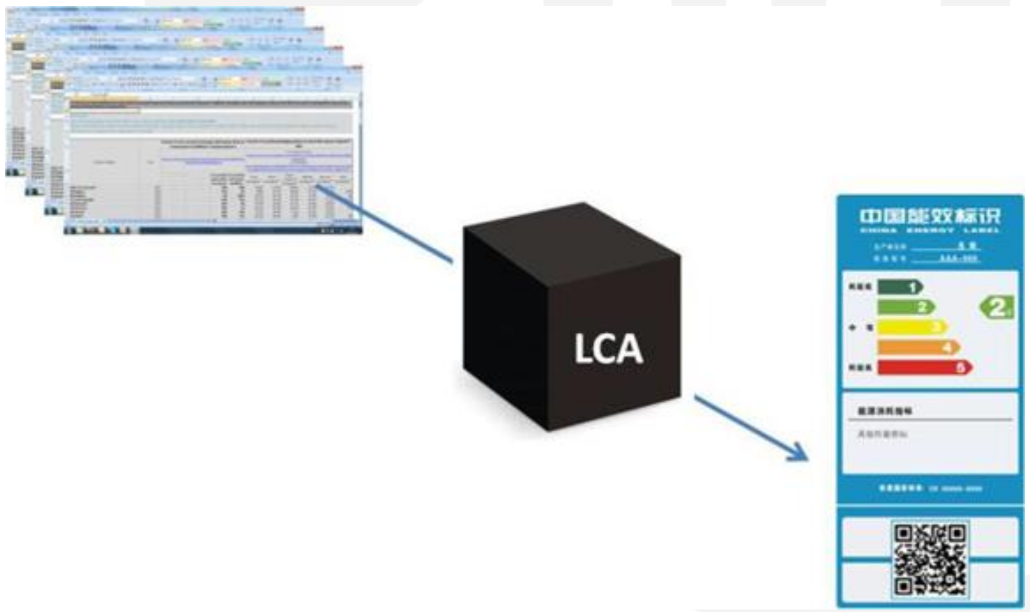
LCA and LCC can support the local decision making process providing scientific results to promote and foster the implementation of sustainable Circular Bioeconomy strategies by:

- Considering the full life cycle and avoiding burden shift, thus preventing the reduction of the environmental and economic impacts in one stage while increasing the impacts at other stages of the life cycle.
- Providing a holistic view on the environmental and economic impacts, rather than optimizing one indicator without considering the (unfavorable) effects on the other indicators.
- Allowing to identify hotspots in the environmental and economic impacts and providing insight in how to improve processes to achieve reduced environmental and economic burdens.

LCA and LCC: outcomes

The main LCA and LCC outcomes are:

- Transparent results on the environmental and economic impact generated.
- Recommendations in line with existing legislation to achieve EU targets.
- Suggestions to minimize impacts of the investigated systems (products, processes or services) by identifying the hotspots and by comparing them with alternative systems with the same function.
- Support to local development.



LCA and LCC: Limitations

The main criticalities of these methodologies are:

- LCA and LCC studies depend on assumptions and scenarios, as they assess the real world in a simplified model.
- Assumptions, scenarios and scope may vary from one study to another, leading to different results.
- Performing LCA and LCC studies is resource and time consuming, mainly due to the large amount of needed data.
- Lack of primary data affects the reliability of the study (not leading to solid conclusions).
- Communicating the LCA and LCC results to the layman is difficult. Indeed, often there is no "one-size-fits-all" solution. Therefore, one may be faced with the difficult choice of which environmental and economic aspect should be given priority. For example, it can be difficult for decision makers to choose between keeping the current high level of greenhouse gas emissions or reducing the greenhouse gas emissions with adverse effects on water quality and biodiversity.

LCA and LCC: proposed solutions

- Promotion of standardization and harmonization of data (characterization factors to convert the inputs and outputs into impact categories) ensure the replicability across different studies and European contexts.
- Collaboration with data providers (e.g. biowaste management agencies and research institutions) can play a vital role in ensuring the availability of reliable and up-to-date data required for robust LCA and LCC analyses.

Resource consumption
(energy and materials)

Environmental and Economic
impacts
(local and global)

The BIOCIRCULARCITIES project

The BCC project aimed at fostering the implementation of environmentally and economically sustainable Circular Bioeconomy strategies.

To this end, and to ensure greater replicability at the European level, three different biowaste management chains were selected for the BCC pilot areas:

- Metropolitan Area of Barcelona (MAB, Spain)
- Metropolitan City of Naples (MCN, Italy)
- Pazardzhik Province (PP, Bulgaria)

For each case study, the environmental and economic sustainability of the current (BaU) biowaste disposal scenario was analyzed, through the LCA and LCC methodologies, and compared with one or more Alternative scenarios in line with the principles of the circular bioeconomy and the needs of local stakeholders.

Sustainability improvement solutions, such as prevention measures, improved waste collection systems and biowaste valorisation treatments (e.g., providing added value products), were identified, according to the territorial vocation.

Conclusions from LCA & LCC in the pilots

The Circular Bioeconomy solutions proposed (prevention measures, different collection systems and treatment) in the Alternative scenarios resulted to be more sustainable than the current biowaste management solutions both from an environmental and economic point of view.

The Alternative scenarios always turn out to be the most sustainable options, since they provide bioproducts that can replace their fossil counterparts.

The results show that the most **impacting processes from an environmental point of view** are **electricity** consumption and transport. These results are useful for the local stakeholders and policymakers to understand the importance of focusing on: (i) energy efficiency strategies and (ii) valorization at territorial level, in order to promote local economies and reduce the impact of transport.

The most relevant results, from an environmental and economic point of view, are:

- For MAB the purification of biogas into biomethane results to be more sustainable than biogas conversion into electricity.
- For PP the valorisation of lignocellulosic fraction by producing biochemicals (biorefinery) allows to achieve greater benefits than other valorisation scenarios (energy valorisation through CHP plants or composting).
- For the MCN the valorisation of silverskin as compost is less advantageous than its transformation into a functional ingredient for bakery products.

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Exploring the circular bioeconomy potential in cities

Thank you

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