PACKALL

PackAlliance:
European alliance for innovation training
& collaboration towards future packaging

Linking Academy to Industry.

Training program: modules

- New materials and biomaterials
- **Eco-design & novel manufacturing processing**
- Citizen and Consumer Engagement
- Residue management and valorisation

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of the European Union

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Life cycle assessment

What is LCA?

What is it for?

Why is it important to do it?

How you do it?

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1. What is LCA?

According to SETAC (Society of Environmental Toxicology and Chemistry), it is a calculation approach that allows to evaluate the environmental impacts of a product, process or activity by identifying and quantifying the consumption of materials and energy and emissions into the environment for the identification and evaluation of opportunities to reduce the impacts .

The analysis covers the entire life cycle of the product ("from cradle to grave"): from the extraction and processing of raw materials, to the production, transport and distribution of the product, to its use, reuse and maintenance, up to recycling and to the final placement of the product after use.

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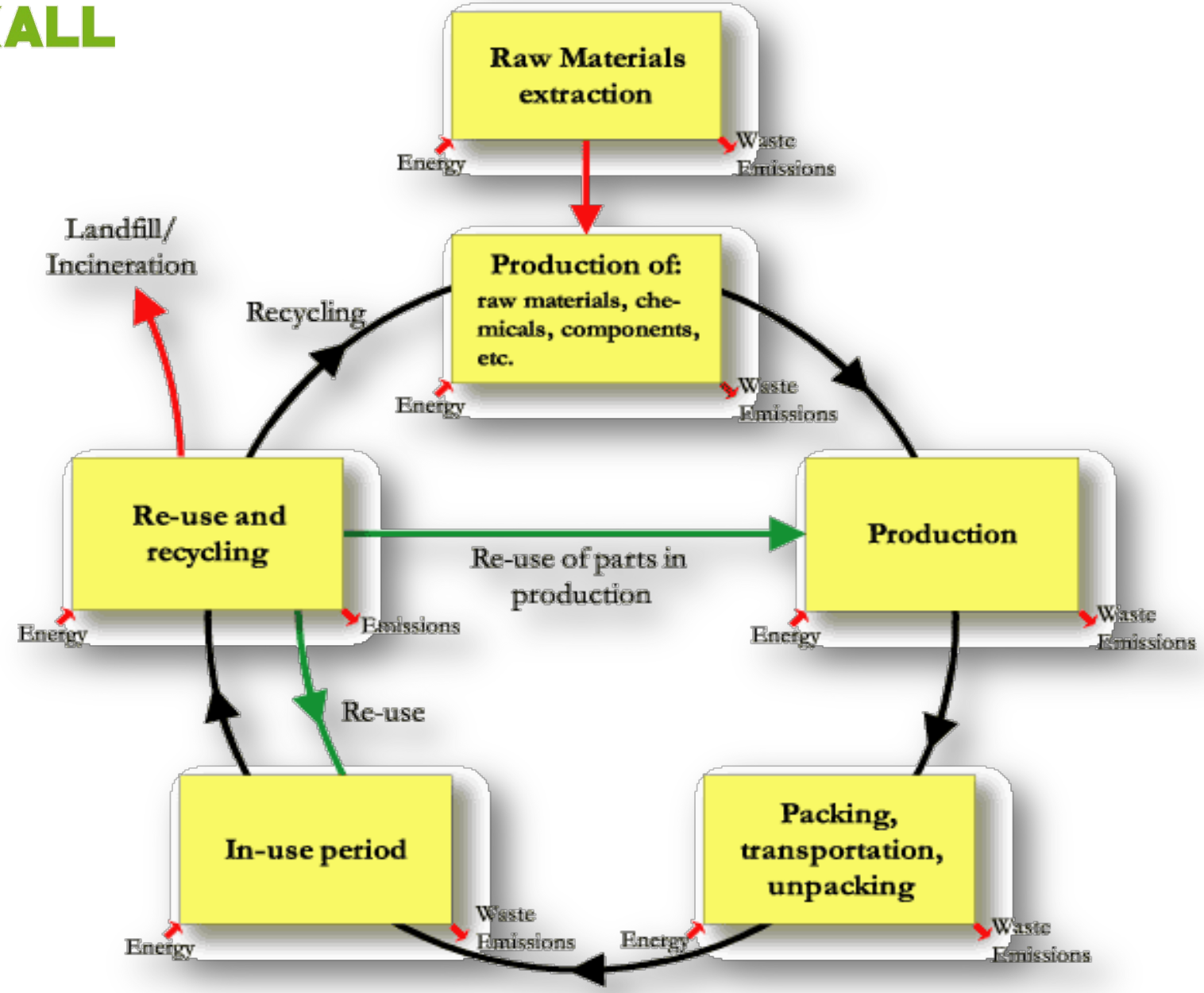

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Regulatory aspects

The UNI EN ISO 14000 standards, which we generally call ISO 14000, provide any organization with the tools necessary to improve the management of the environmental variable for all types of activities, products and services.
ISO 14040 is the standard on Environmental Management - Life Cycle Assessment - Principles and Framework in which LCA is defined as: "The compilation and evaluation of the incoming and outgoing flows throughout the life cycle, as well as the potential environmental impacts of a product system“
ISO 14044 replaced the previous versions from ISO 14041 to ISO 14043. It was developed for the preparation, management and critical review of the life cycle. It contains everything that was contained in the previous regulations and in addition it says that “LCA studies the environmental aspects of a product through the various stages of its life, from the "cradle to the grave": from the extraction of the raw material, including transport, to the final disposal of the product.

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Main steps in an LCA study

1. Definition of the objectives and boundaries of the analysis;
2. Compilation of a life cycle inventory (what enters and what exits);
3. Evaluation of the potential environmental impacts associated with what enters and what exits;
4. Interpretation of the results and in particular analysis of inventories and estimation of the impacts in relation to the study objectives.

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Main limitations

1. It doesn't fit all cases
   For example, cost aspects are generally not considered
2. There are structural limitations
   It cannot indicate local impacts and has a stationary approach
3. It is subjective
4. It is limited in time
5. It is influenced by the availability of data

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For example…

Is glass or plastic packaging better for a drink?

For both options, all stages of the life cycle must be examined.

For glass bottles, the stages are: the extraction of glass minerals from the biosphere, the production of the bottle, the bottling of the contents, transport and final disposal.

For plastic bottles, the stages consist of the production of crude oil, refining, the production of polymers, the manufacture of the bottle, the bottling of the contents, transport and final disposal.

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All process chains related to auxiliary materials and services must then be taken into consideration.
For example, a catalyst is required for the production of polymers; this element must therefore be included in the life cycle and its impacts must be calculated through "impact allocation" rules.
The environmental flows generated by this series of processes must be inventoried and are, for example, emissions into air, water or soil, biosphere resources, land use, or energy production.
These flows must then be processed for both solutions (glass and plastic) always on the basis of their associated impacts; by comparing them, it is possible to arrive at a fair assessment that considers all the environmental aspects of the product life cycle.

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We have to define:

- the purpose of our study
- the functional unit
- the boundaries of the system
- data quality requirements

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Aim of the study

What is my goal?
What do I want to achieve?
What is the expected application?
To whom should the results of the study I am doing be communicated?

Functional unit

the product, service or function on which to set the analysis and comparison with possible alternatives
kg of product, t of waste treated, kWh of energy supplied….
a reference to which to link the outgoing and incoming flows

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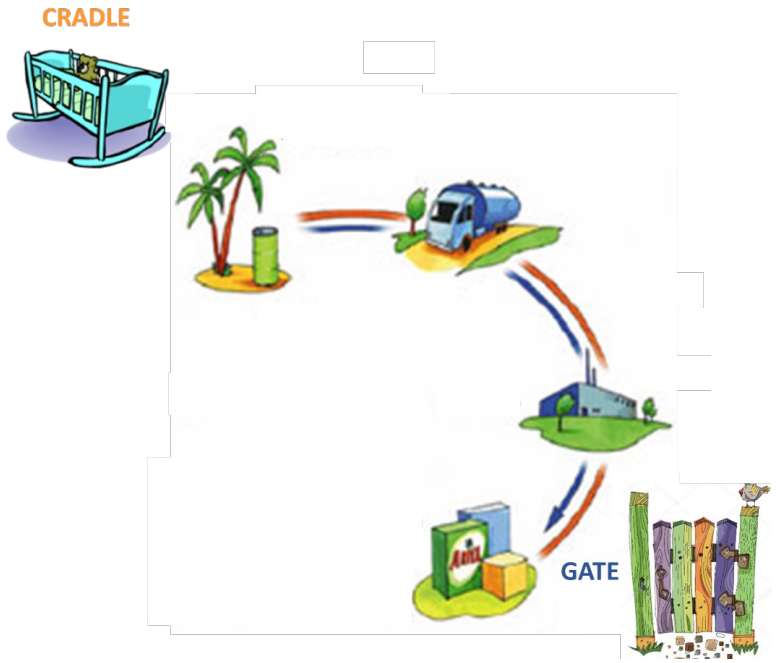
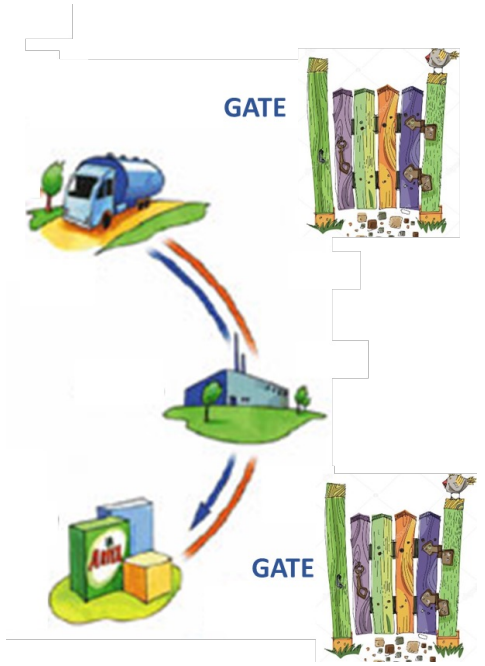
The boundaries of the system

It is necessary to identify the sequence of elementary stages of the process in order to have only energy and raw materials in and out only waste.

And then you need to know where to go ...

Different approaches: “cradle-to-grave”, “cradle-to-gate”, “gate-to-gate”





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The quality of data

We need to fix:

- the time coverage; i.e., the age of the data (eg last five years);
- the duration of their collection (eg one year);
- the geographic coverage; i.e., the area in which the data will be collected (eg local, regional, national, continental or global);
- the technological coverage; i.e., which technology to apply in data collection.
- the source of the data:
  - ✓ if measured, the instruments used must be specified;
  - ✓ if calculated with which algorithms;
  - ✓ if estimated with what statistical methods.

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Stages of compiling the inventory:

- ✓ preparation for data collection;
- ✓ data collection;
- ✓ data validation;
- ✓ data recording per process unit;
- ✓ data aggregation;
- ✓ review of the system boundaries.

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Stages of compiling the inventory:

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- ✓ review of the system boundaries.

The data can come from different sources so we have to:

- create a flow chart with all the elementary units;
- describe in detail each elementary unit with the data categories associated with each process;
- make a list of the units of measurement of the data;
- describe the data collection techniques for each category.

We have:

FOREGROUND DATA

they refer to specific data to be acquired to model the system;
they are specific of a particular product

BACKGROUND DATA

they are given for the production of generic materials, for the production of energy, for transport, for waste management;
they are obtained from databases and literature.

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Stages of compiling the inventory:

- ✓ preparation for data collection;
- ✓ data collection;
- ✓ data validation;
- ✓ data recording per process unit;
- ✓ data aggregation;
- ✓ review of the system boundaries.

The data must be collected for each internal process unit at the system boundary; therefore, for each process unit the beginning and the end must be described.

But remember that the data sources can be different:

- ✓ Primary data sources: the data are obtained from the production site;
- ✓ Secondary data sources: taken from the literature (in this case the source must be noted);
- ✓ Tertiary data sources: obtained with the use of estimates or technical coefficients.

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Stages of compiling the inventory:

- ✓ preparation for data collection;
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- ✓ review of the system boundaries.

We need to validate data through mass and energy balances

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Stages of compiling the inventory:

- ✓ preparation for data collection;
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Data have to be referred to the elementary functional unit…

…we pass from kg to kg/FU

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Stages of compiling the inventory:

- ✓ preparation for data collection;
- ✓ data collection;
- ✓ data validation;
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- ✓ review of the system boundaries.

The individual elementary process units are interconnected and this makes it possible to compare the individual units and evaluate the entire process. Aggregation is the grouping of data from different elementary units and can only be done if the data relate to equivalent substances or similar environmental impacts.

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Stages of compiling the inventory:

- ✓ preparation for data collection;
- ✓ data collection;
- ✓ data validation;
- ✓ data recording per process unit;
- ✓ data aggregation;
- ✓ review of the system boundaries.

Now we can:

- Exclude insignificant flows or units;
- Exclude flows that are irrelevant for the purposes of the study;
- Include new process units (if needed).

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We need:

- ✓ a software;
- ✓ some databases;
- ✓ a method

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Software

SimaPro

suitable for detailed studies 

it is possible to take into account data uncertainty 

it is the most used software and therefore has a robust architecture 

expensive 

requires high PC performance 

GaBi

possibility of introducing non-linear relations programmed by the user 

not very flexible in the interpretation phase 

some tools must be downloaded separately and software updates are frequent 

OpenLCA

open source 

less powerful than other software 

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Databases

- ✓ These are the "background data" we saw earlier ...
- ✓ The databases (of which the most complete is the Ecoinvent) contain data on thousands of products
- ✓ They are implemented in software
- ✓ Each database can be implemented in different software

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Methods

- ✓ Midpoint approach: single categories of damage
- ✓ Endpoint approach: aggregated data
- ✓ Integrated approach

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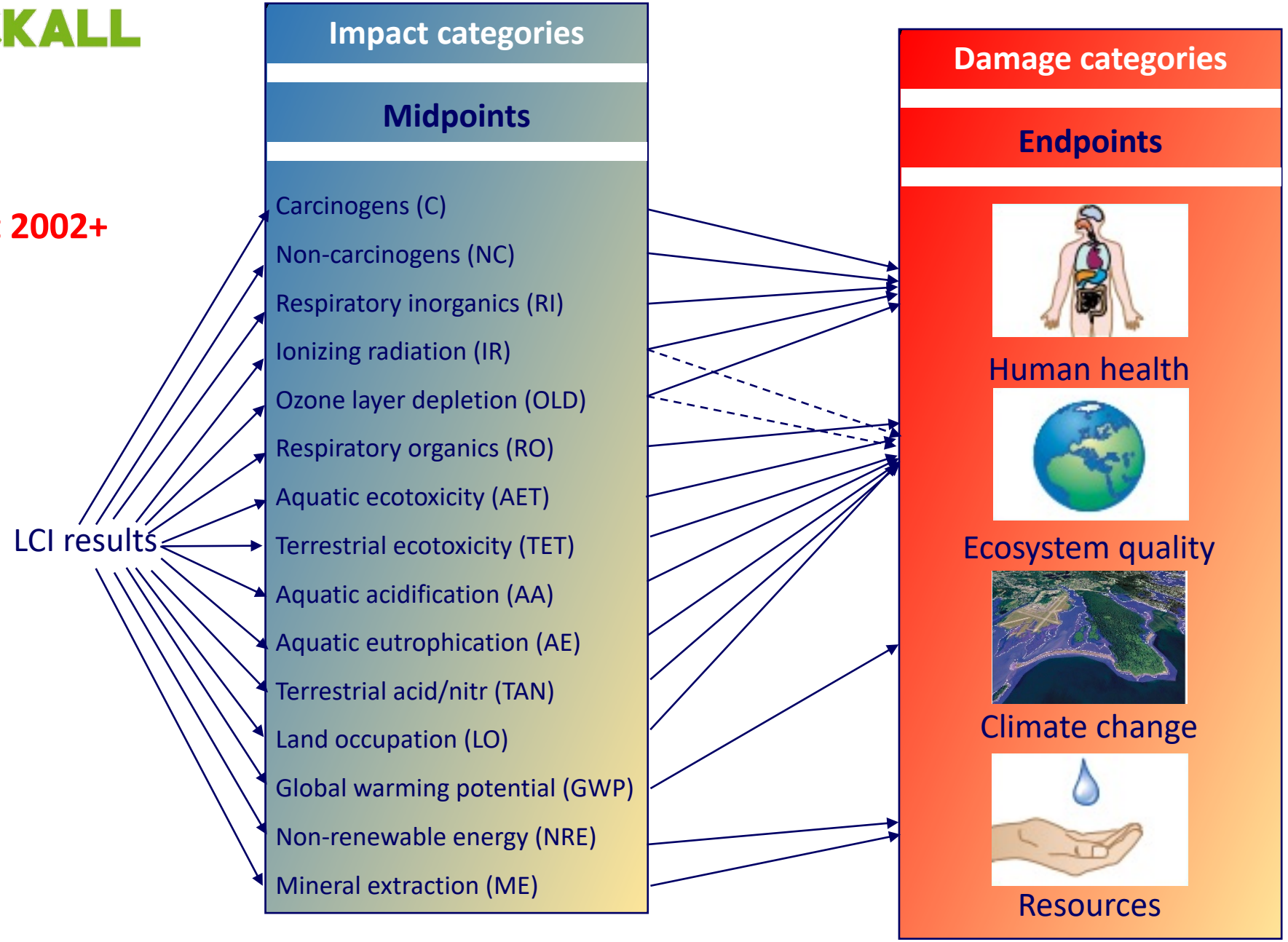

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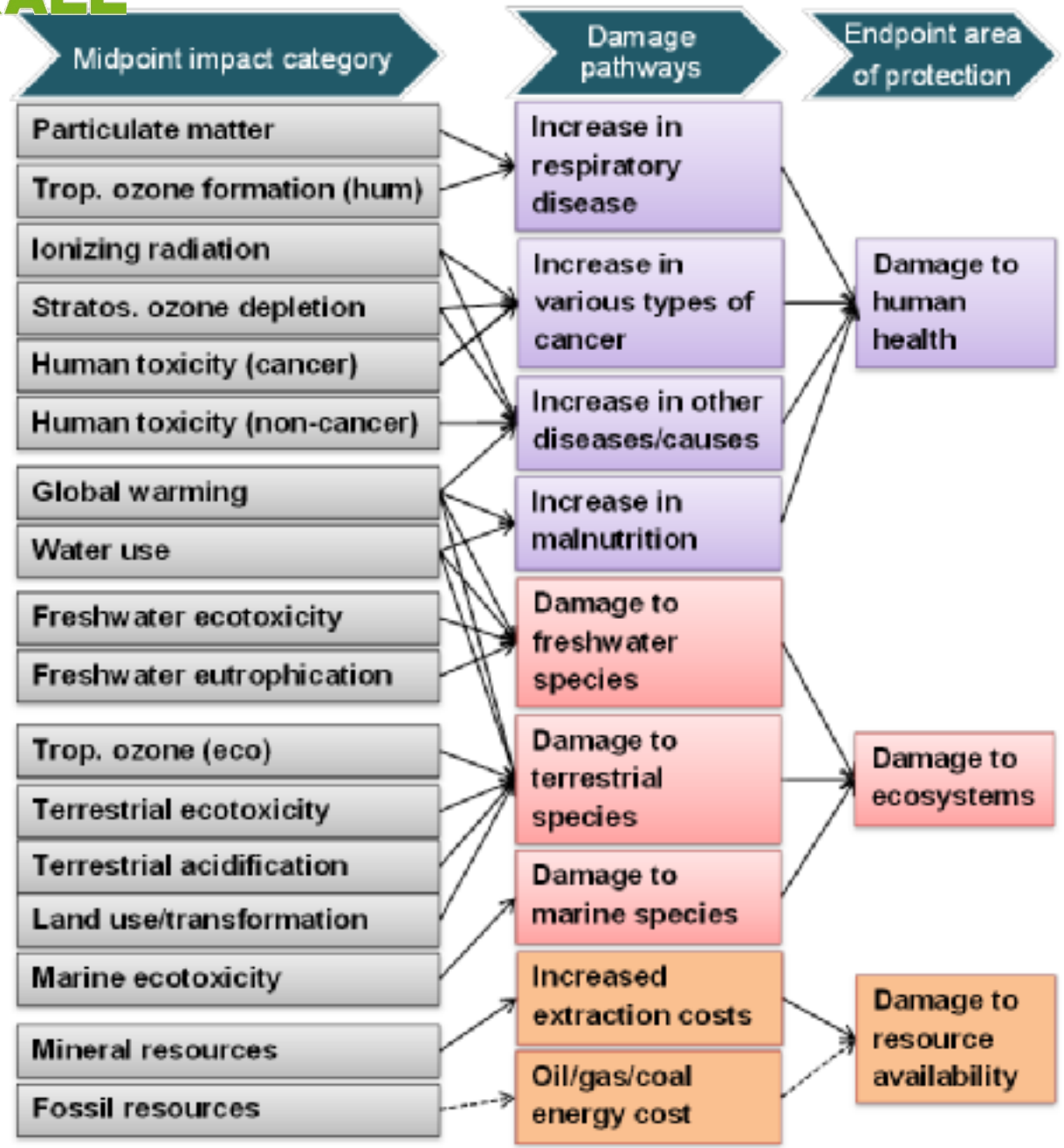
ReCiPe



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- Identification of the highest impacts
- Identification of critical points on the life cycle
- Data uncertainty analysis
- Sensitivity analysis
- Conclusions and recommendations

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