ALMA MATER STUDIORUM
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Life Cycle Assessment methodology (LCA) applied to the case study of a pyrolysis process performed on End-of-Life Tires

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Purpose of the study

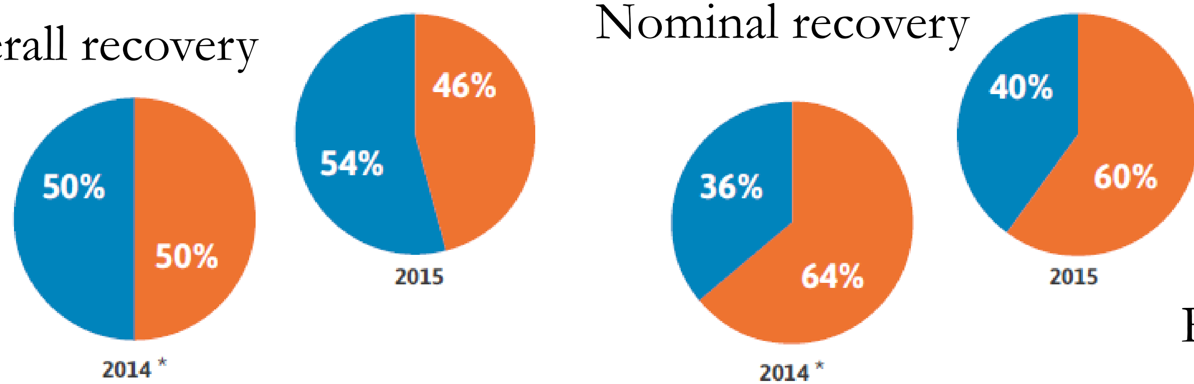
This work proposes an assessment of the environmental impacts of the **pyrolysis process of End of Life Tires (ELT)**, performed by a company ("Curti s.p.a."), and to compare it with alternative scenarios of valorisation and/or disposal.

LCA (**life cycle assessment**) methodology in order to determine the **most critical stages of the process investigated**, the **environmental benefits arising from the recovery of materials and energy** and the **greater or lesser impact comparing the technology with others recovering material or energy, already present on the market**.

Description of the context

Overall recovery

Nominal recovery



Material ● ● Energy

(Source: Ecopneus Report 2015)

Description of the context

ELT generation

Collection

Storage

Grinding / Crushing / Pulverisation

Material recovery (source: Ecopneus Report 2015)

Uses of **grinded** material

Electric Energy

Cement factories

Road paving

Uses of **granulated** material

Synthetic pitches

Athletic flooring

Acoustic insulation

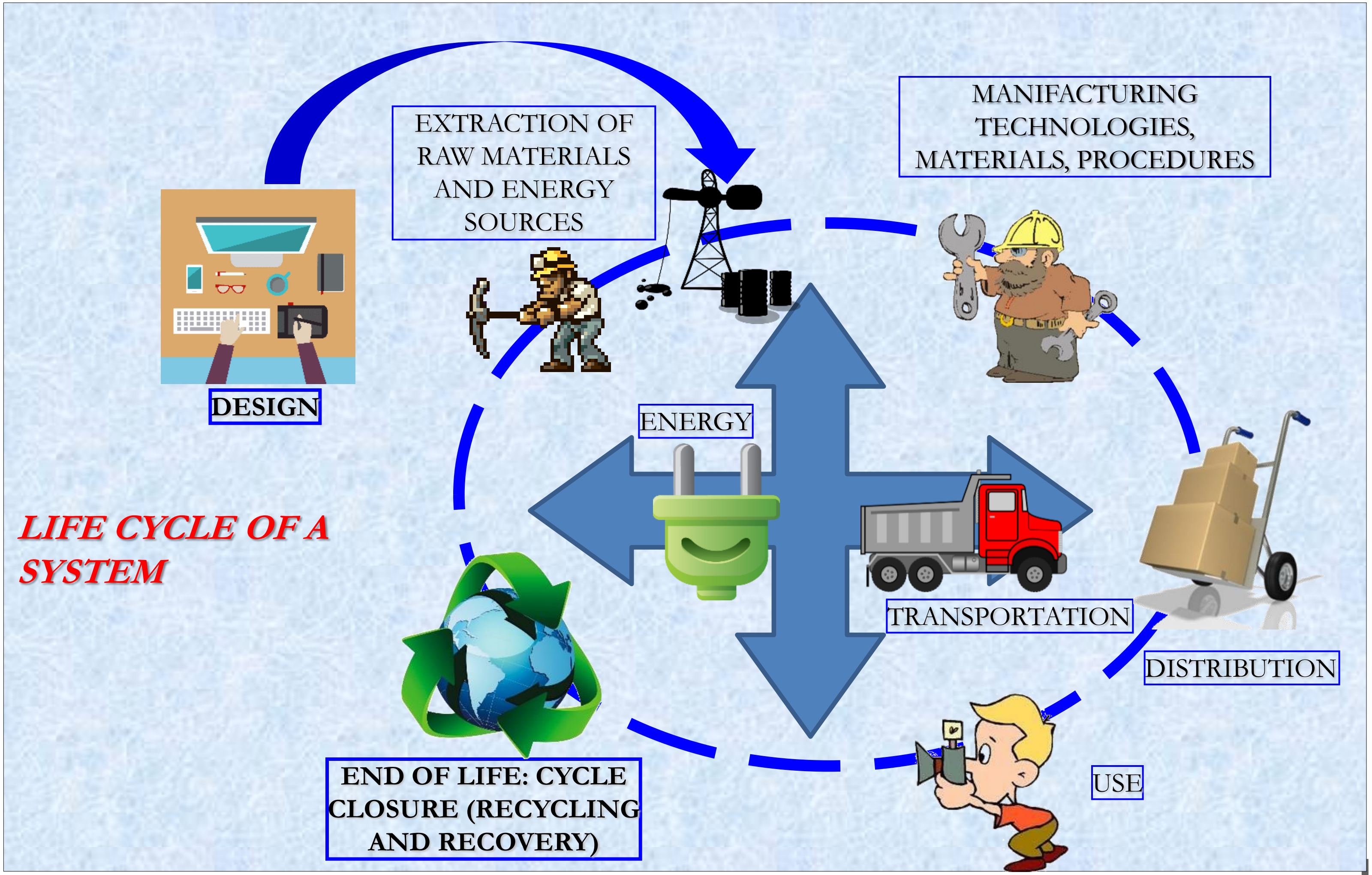
Uses of **pulverised** material

Asphalt

Sealant

Rubber goods

LCA approach



ISO 14040 and 14044 (2006)

Goal & Scope Definition:

- Determine the scope and system boundaries

Life Cycle Inventory:

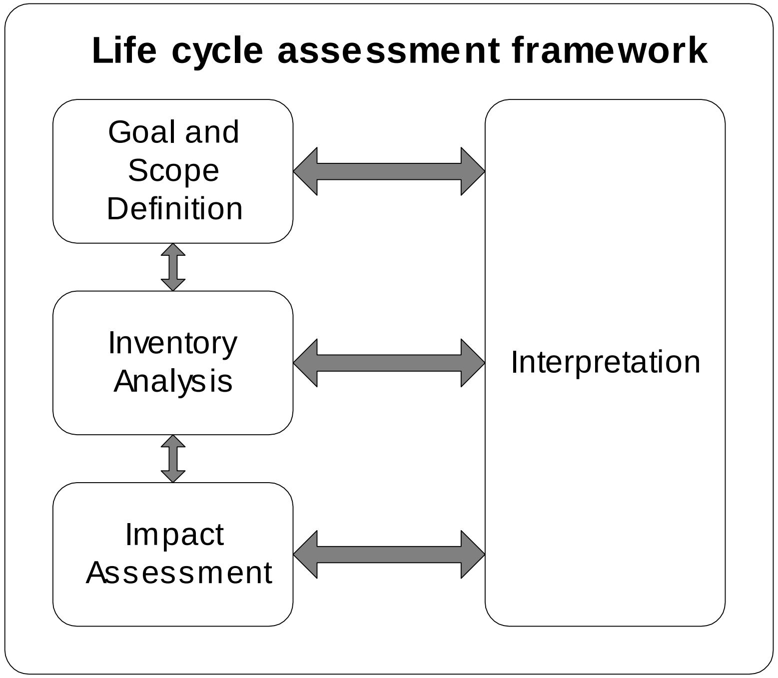
- Data collection, modeling & analysis

Impact Assessment:

- Analysis of inputs/outputs using category indicators
- Group, normalize, weight results

Interpretation:

- Draw conclusions
- Checks for completeness, contribution, sensitivity analysis, consistency w/goal and scope, analysis, etc.



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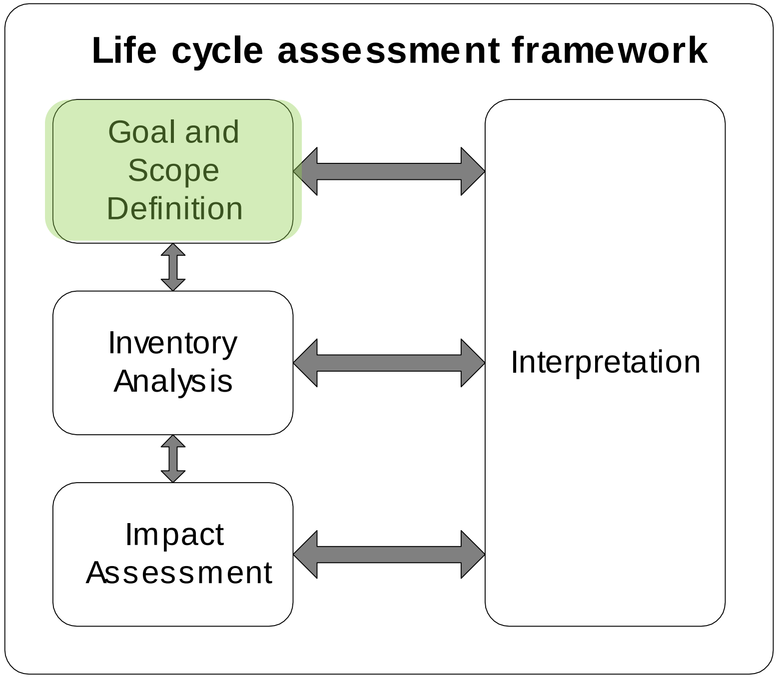

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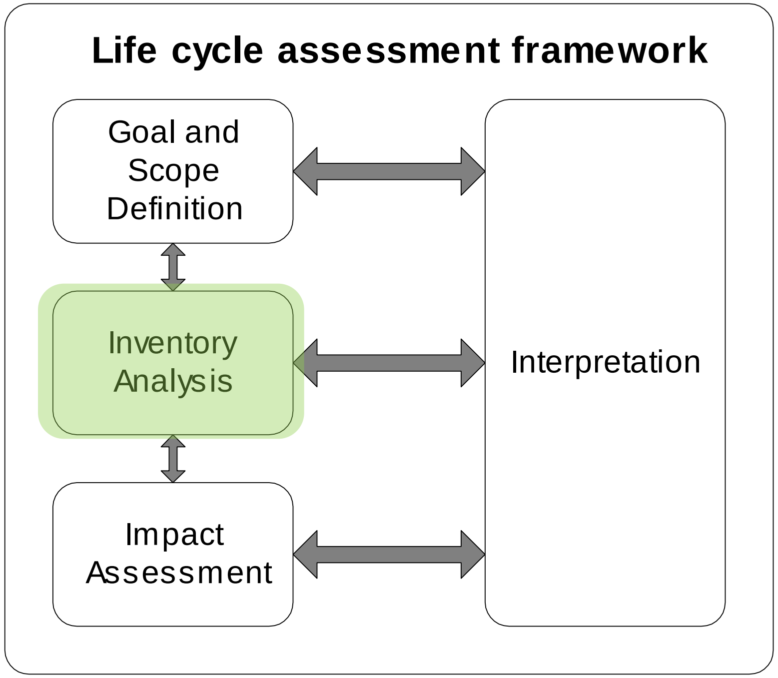

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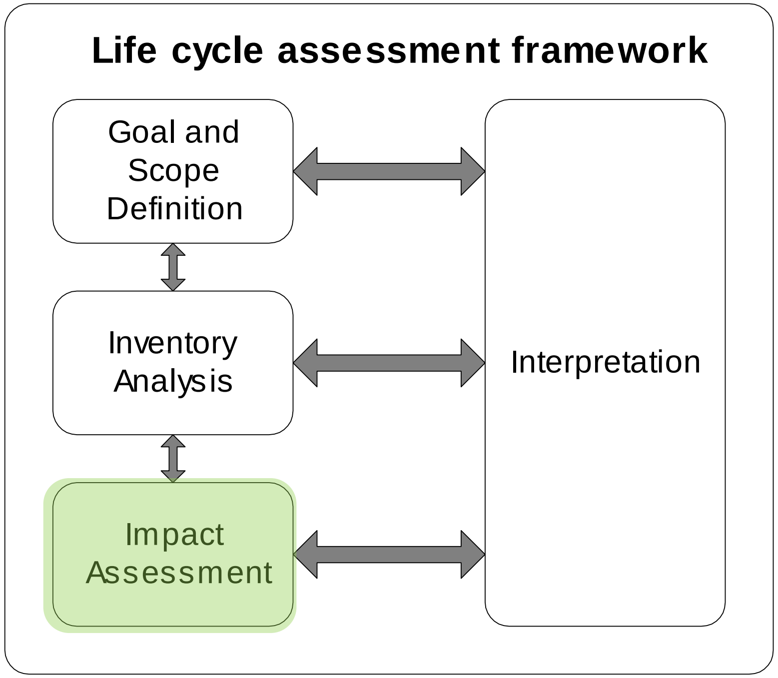

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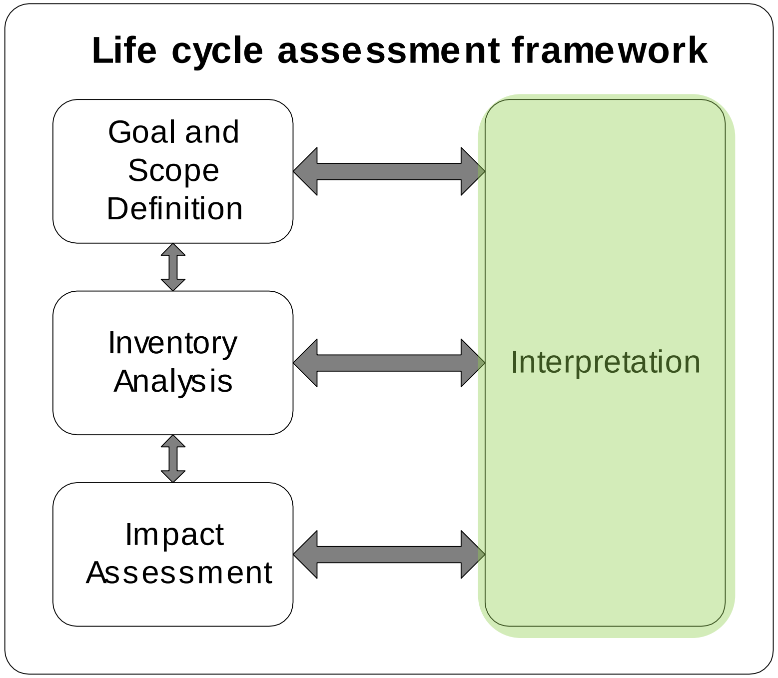
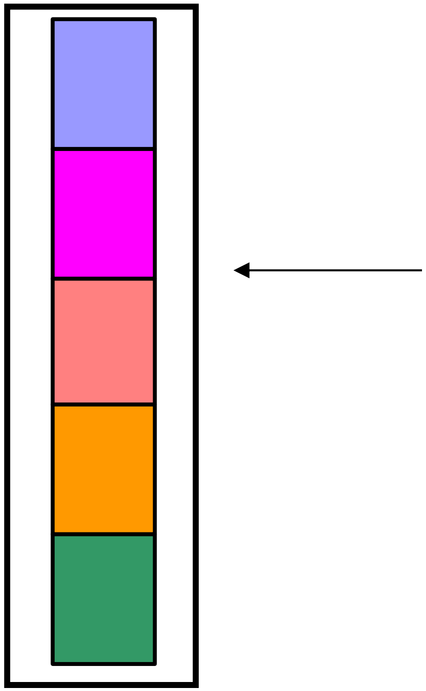


LCA approach

LCA applied to a product

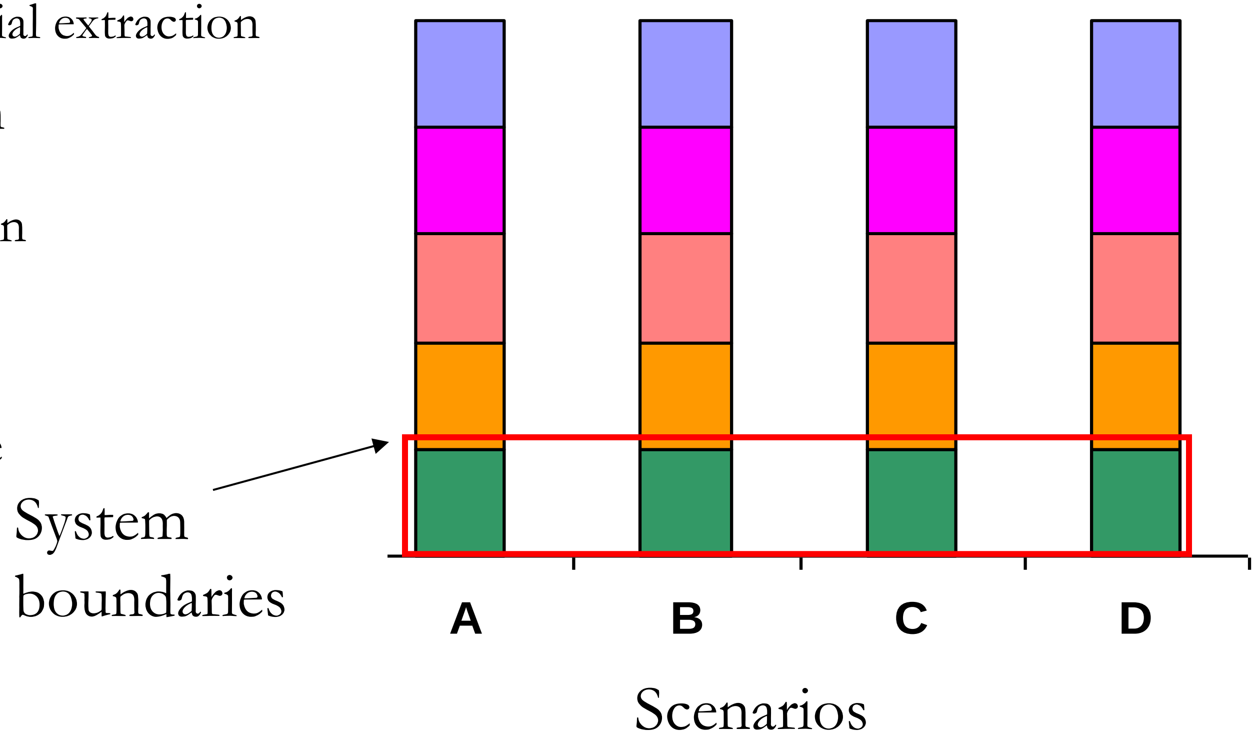
- Raw material extraction
- Production
- Distribution
- Use
- End of life



LCA approach

LCA applied to waste management

- Raw material extraction
- Production
- Distribution
- Use
- End of life



Goal & Scope Definition

Life Cycle phases considered:

-**Treatment process** (including all input and output flows for the supply and distribution of material and energy);

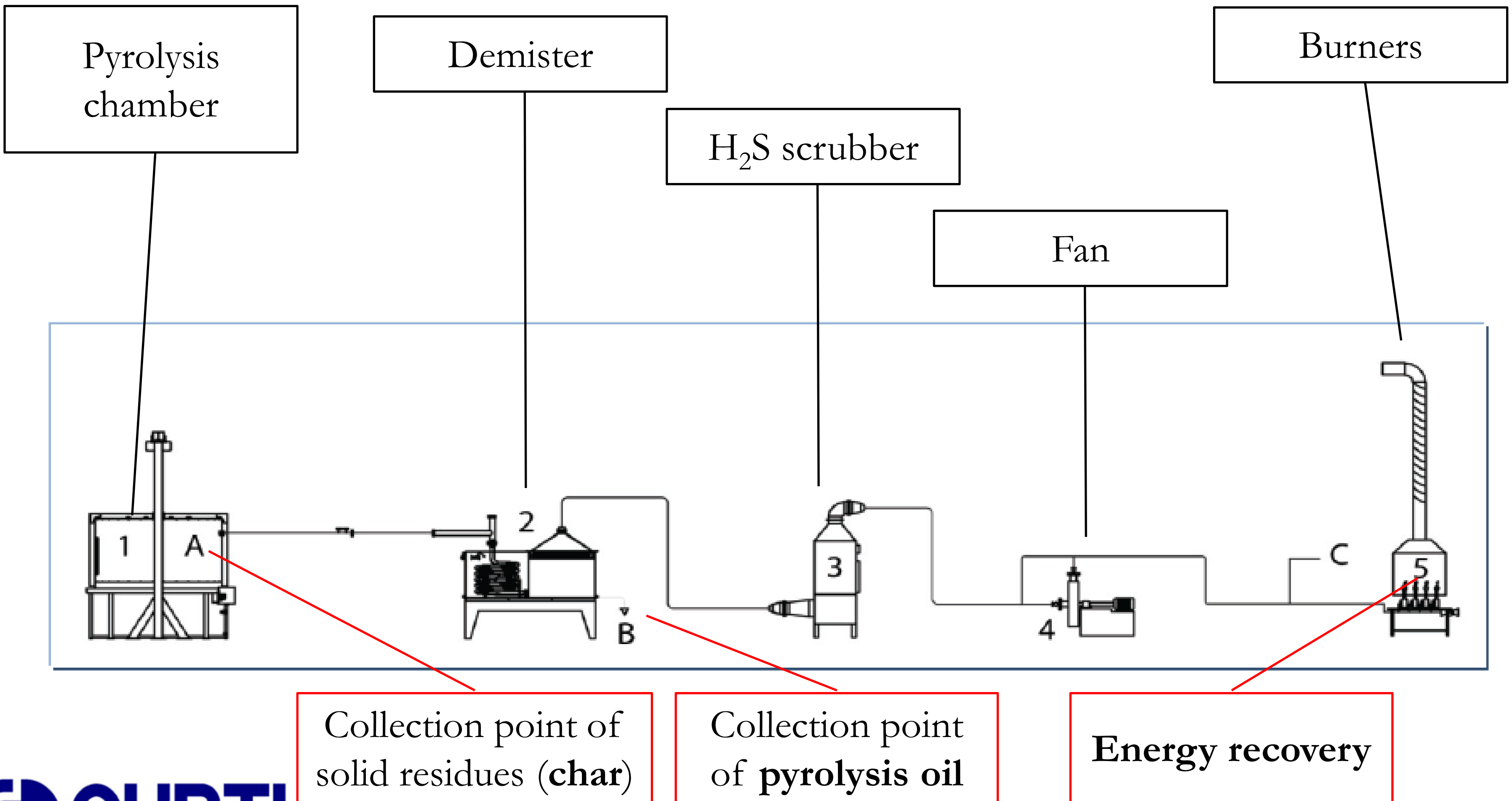
-**Material recovery** (to recycling facilities);

-**Disposal of waste/residues**

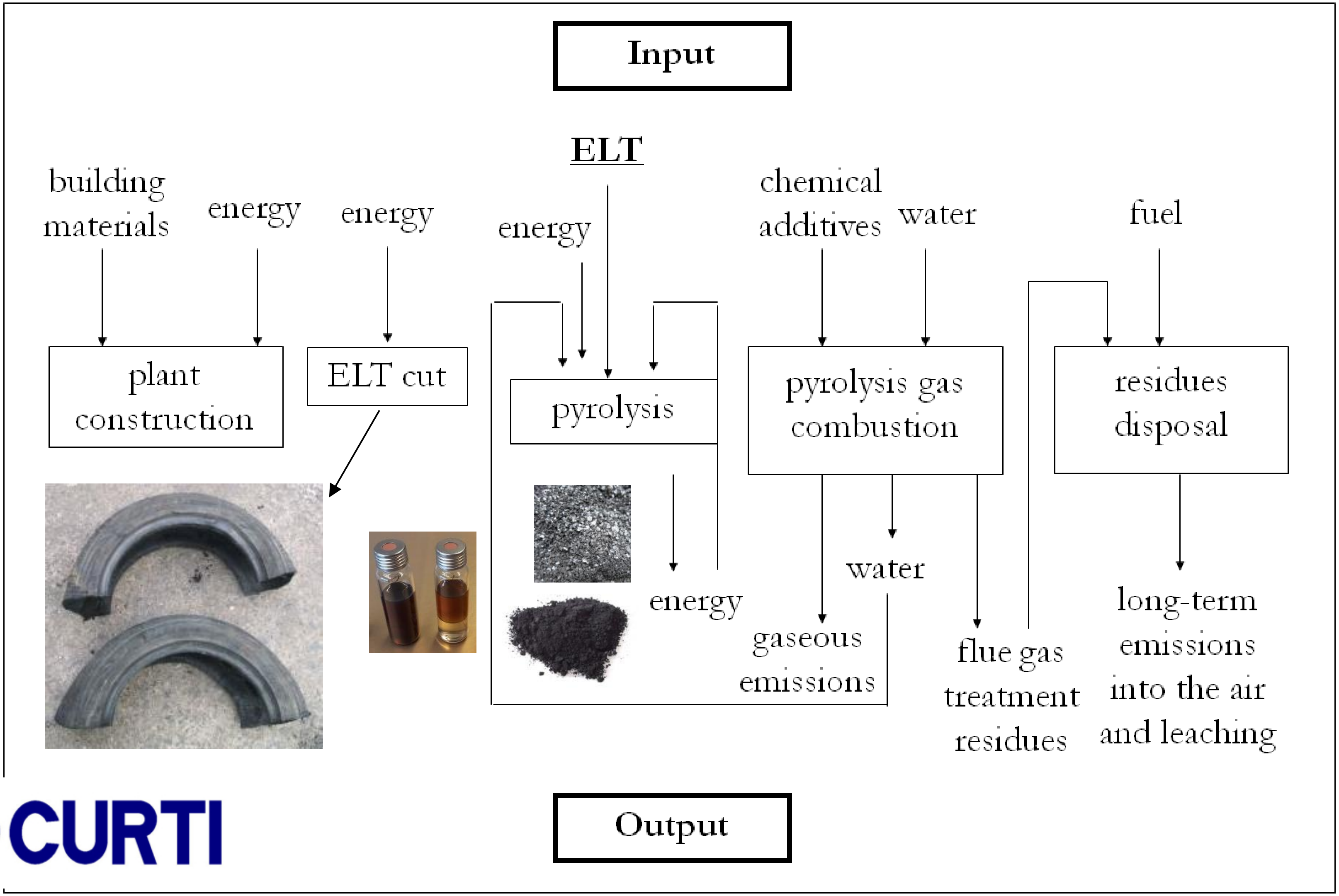
Functional Unit

It is the physical quantity to which all streams and impacts are reported (in input and output): **1 ton of End of Life Tires** has been chosen. In the case of the pyrolysis plant, rated at 4 t/h has been considered.

The case study

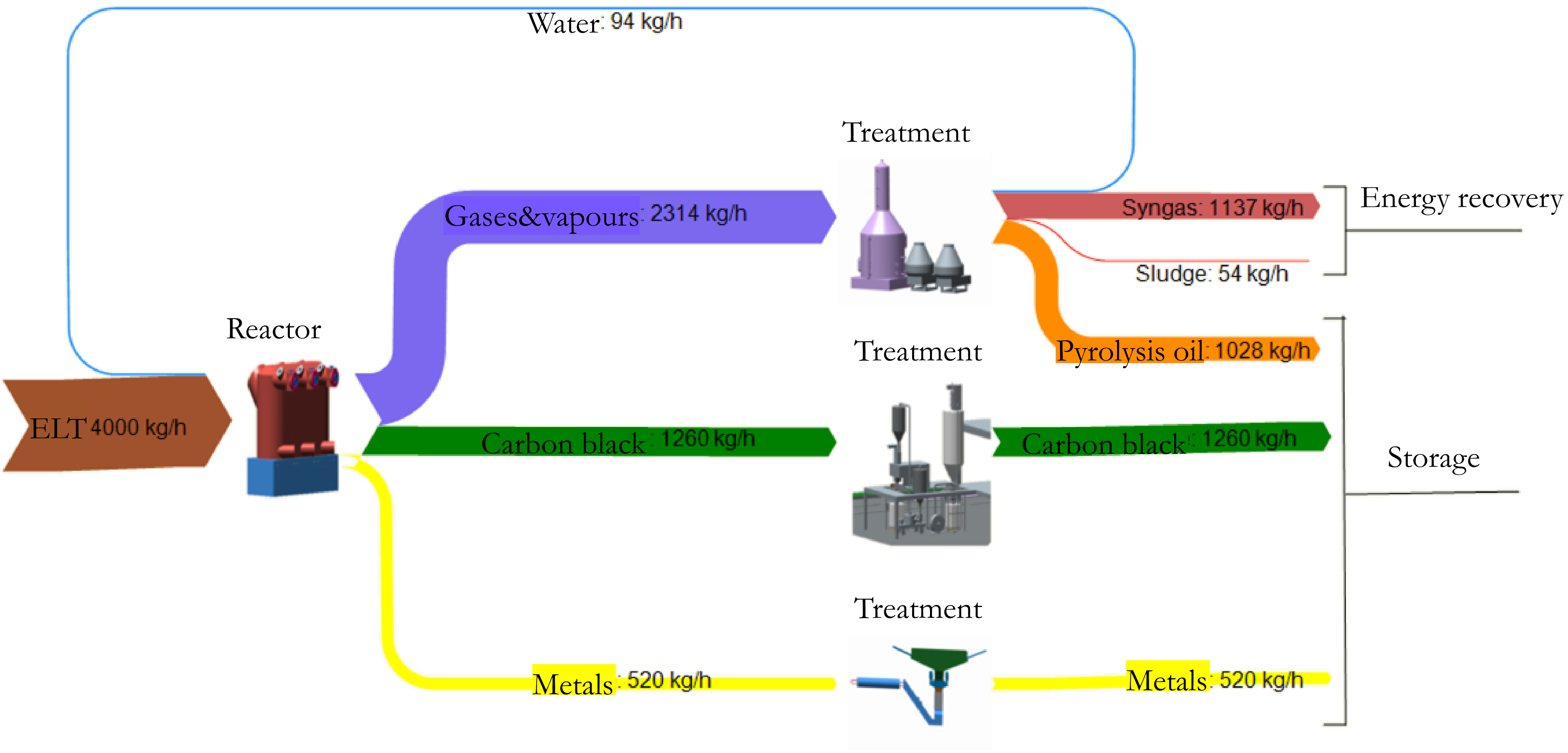


Goal & Scope Definition

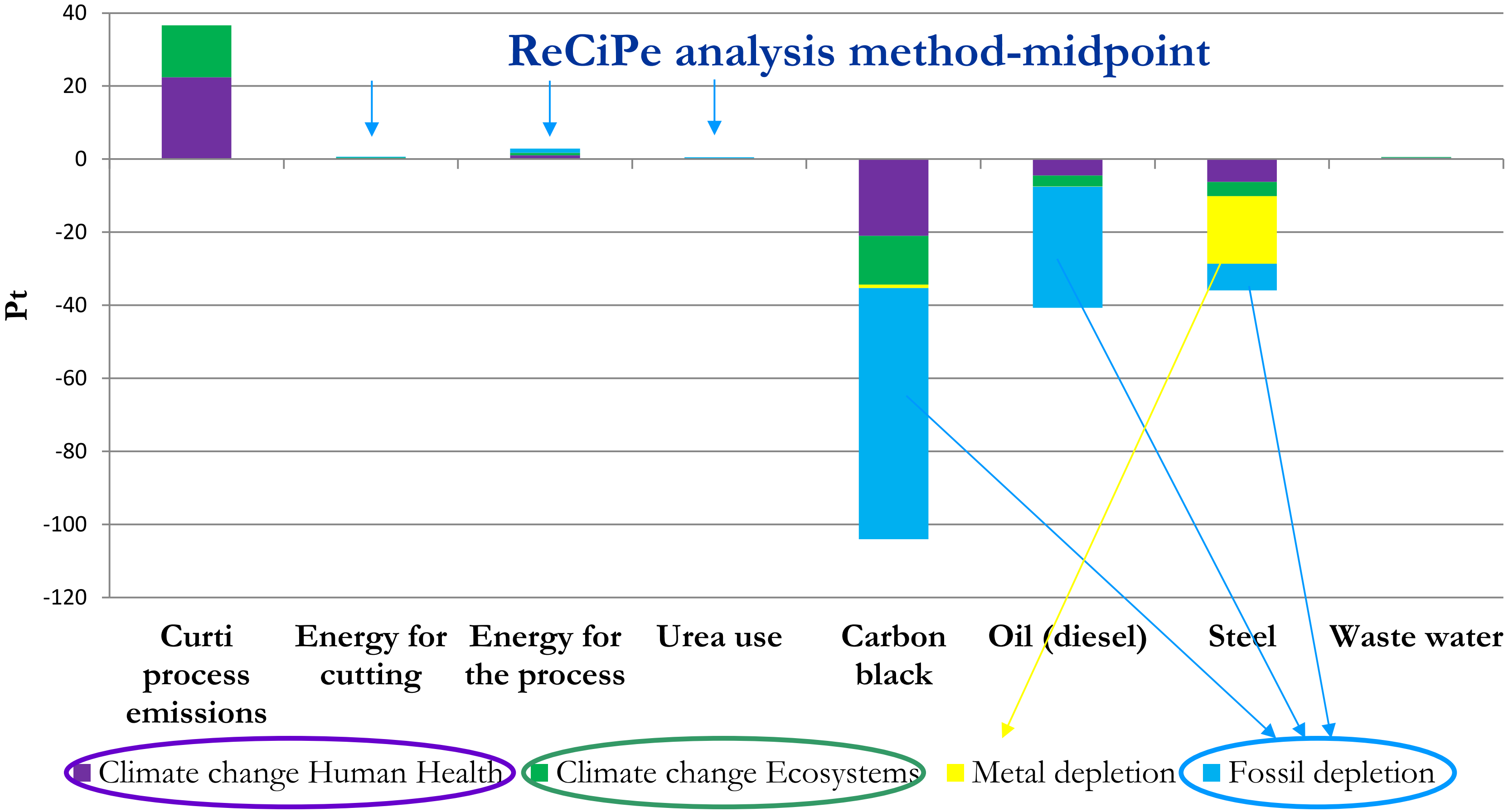


CURTI

Life Cycle Inventory



Life Cycle Impact Assessment: Scenario Pyrolysis "Curti"

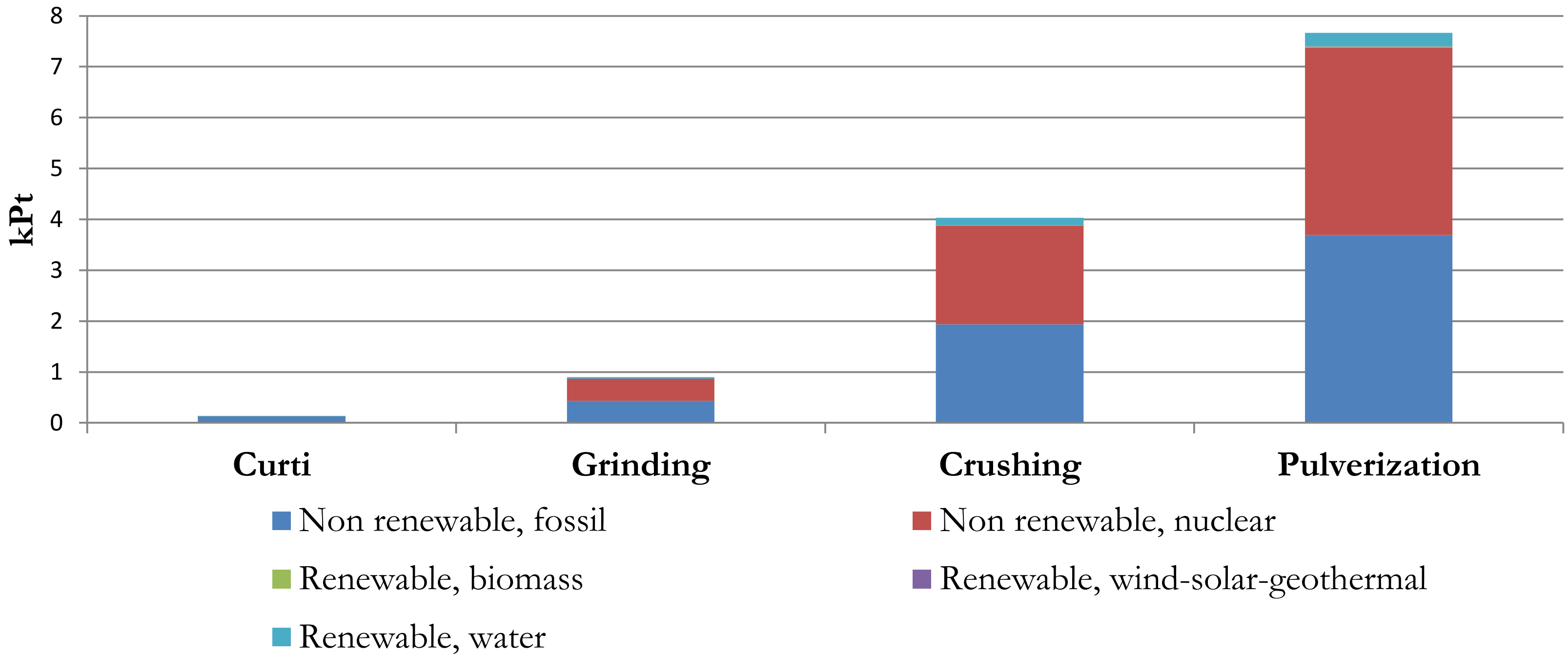


The **avoided impact** due to the **recovery of carbon black, steel and oil** exceeds (more than one order of magnitude) the impact generated by the process (on which energy consumption affects the results of about 10%).

Life Cycle Impact Assessment: Pre-treatment impacts comparison

Cumulative Energy Demand (CED) method

- "**Curti**" (Single cut)
- **Grinding** (for energy recovery processes)
- **Crushing** (for energy/material recovery processes)
- **Pulverization** (for material recovery processes)

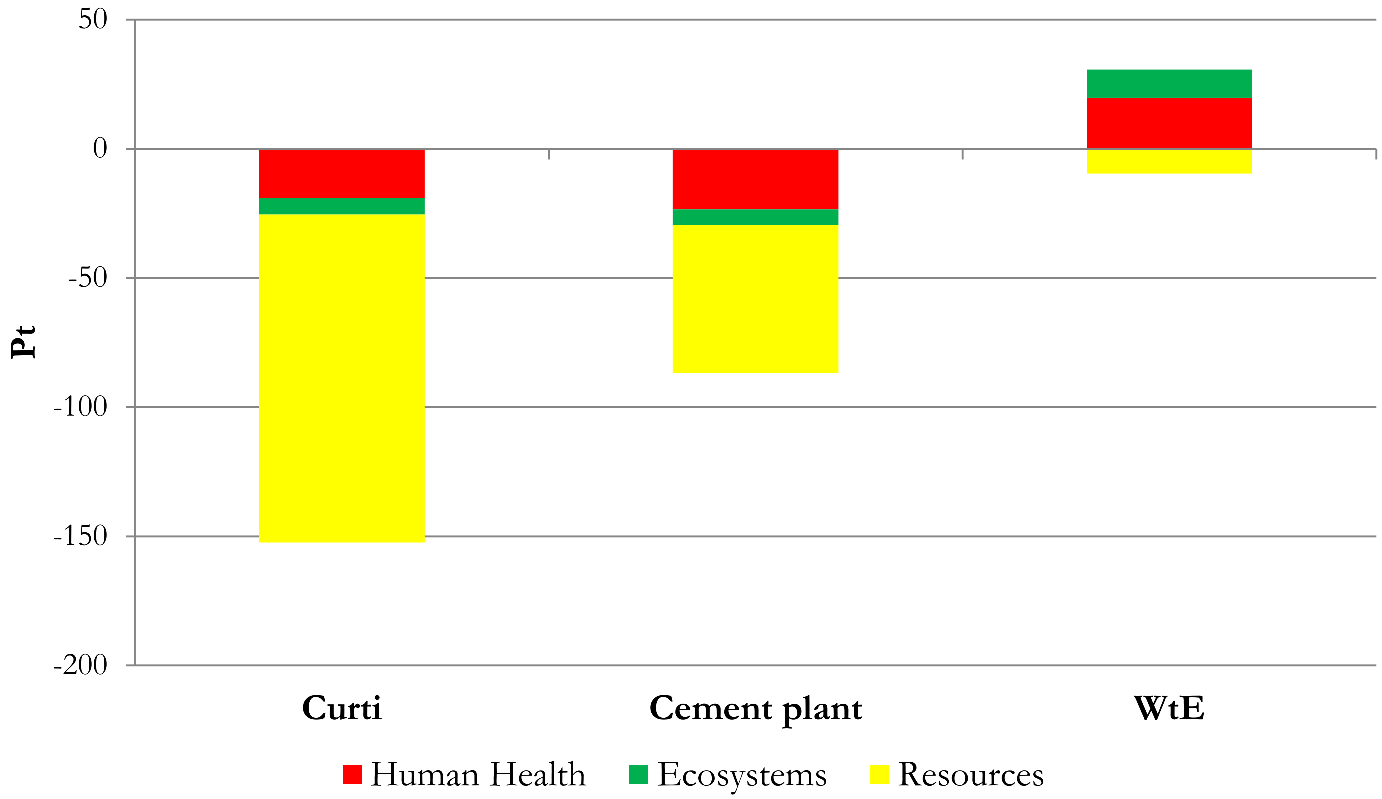


As for the pre-treatment, "Curti" process results in an energy demand equal to 1/3, 1/10, 1/20 compared to the alternative ones

Life Cycle Impact Assessment: Comparison with energy recovery scenarios

ReCiPe analysis method-endpoint

- "**Curti**" pyrolysis process
- **Cement plant**
- **Waste to Energy** (WtE) process

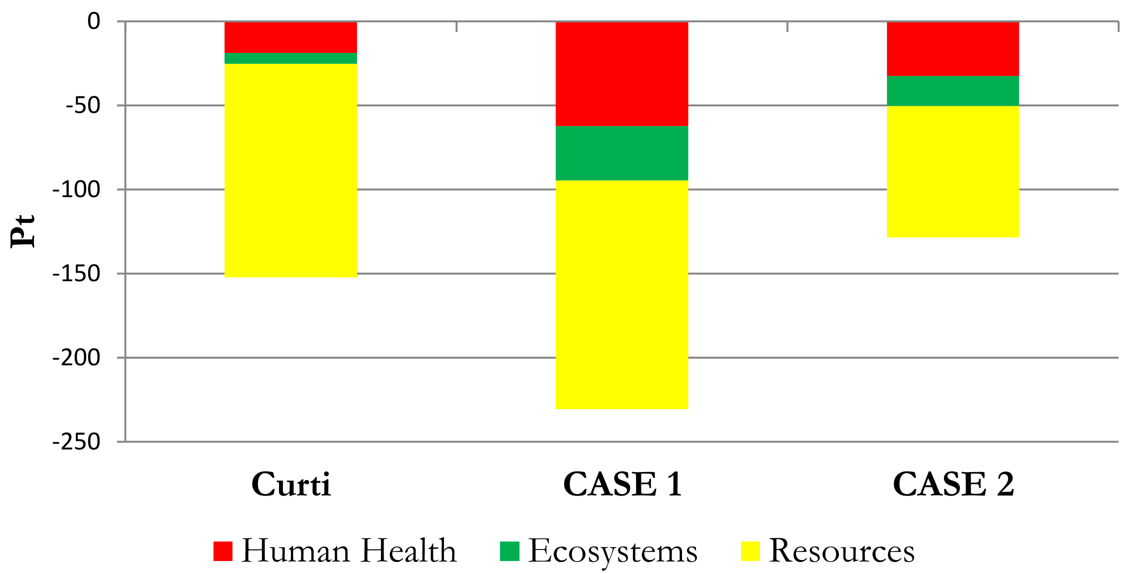


Compared to other energy recovery scenarios, the balance is largely favourable

Life Cycle Impact Assessment: Comparison with material recovery scenarios

ReCiPe analysis method-endpoint

- “**Curti**” pyrolysis process
- **CASE 1: full recovery of metals and synthetic rubber**
- **CASE 2: intermediate option** with recovery of metal, synthetic rubber, sand and bitumen



In the comparison with other recovery scenarios, a great influence is given by the different options of granules recovery, considering which materials should actually be replaced: a complete recovery of metals and synthetic rubber (CASE1) would bring to a greater advantage; intermediate options (CASE 2) would make “Curti” process preferable.

Conclusions

- A pyrolysis process, implying a **chemical transformation** of a waste into valuable materials and energy, was investigated from a **life cycle perspective**.
- The process was found to be favourable in terms of energy consumption, due to the very low requirements in the **pre-treatment step**, compared to the alternatives.
- However, the **greatest impacts** were not those associated to the direct emissions of the process, but the **benefits** coming from the recovery of materials and energy (avoided fossil and mineral depletion).
- According to the different fate of the recycled materials in alternative scenarios, the **greater or lower benefits** coming from pyrolysis could be **questionable**.
- **Other recovery scenarios** could be investigated in the future.
- Furthermore, by applying a **sensitivity analysis** (e.g., Monte Carlo method), the robustness of the model in function of the uncertainty of the data used could better be checked (especially the secondary ones collected from the literature).

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Thanks for your attention!!

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