Use of Life Cycle Assessment to determine the environmental impact of thermochemical conversion routes of lignocellulosic biomass: The gasification step

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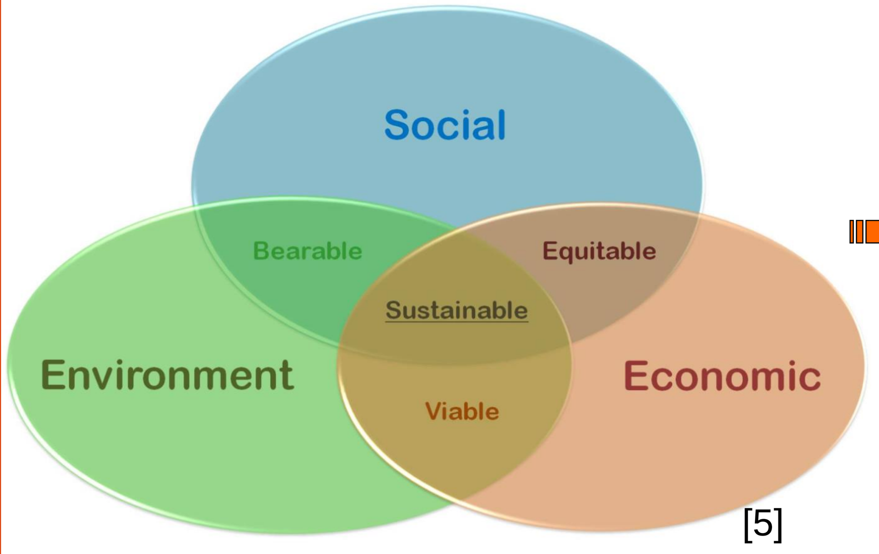
Sustainable development



Issues:
- Population growth
- (Fossil) resources depletion
- Climate change

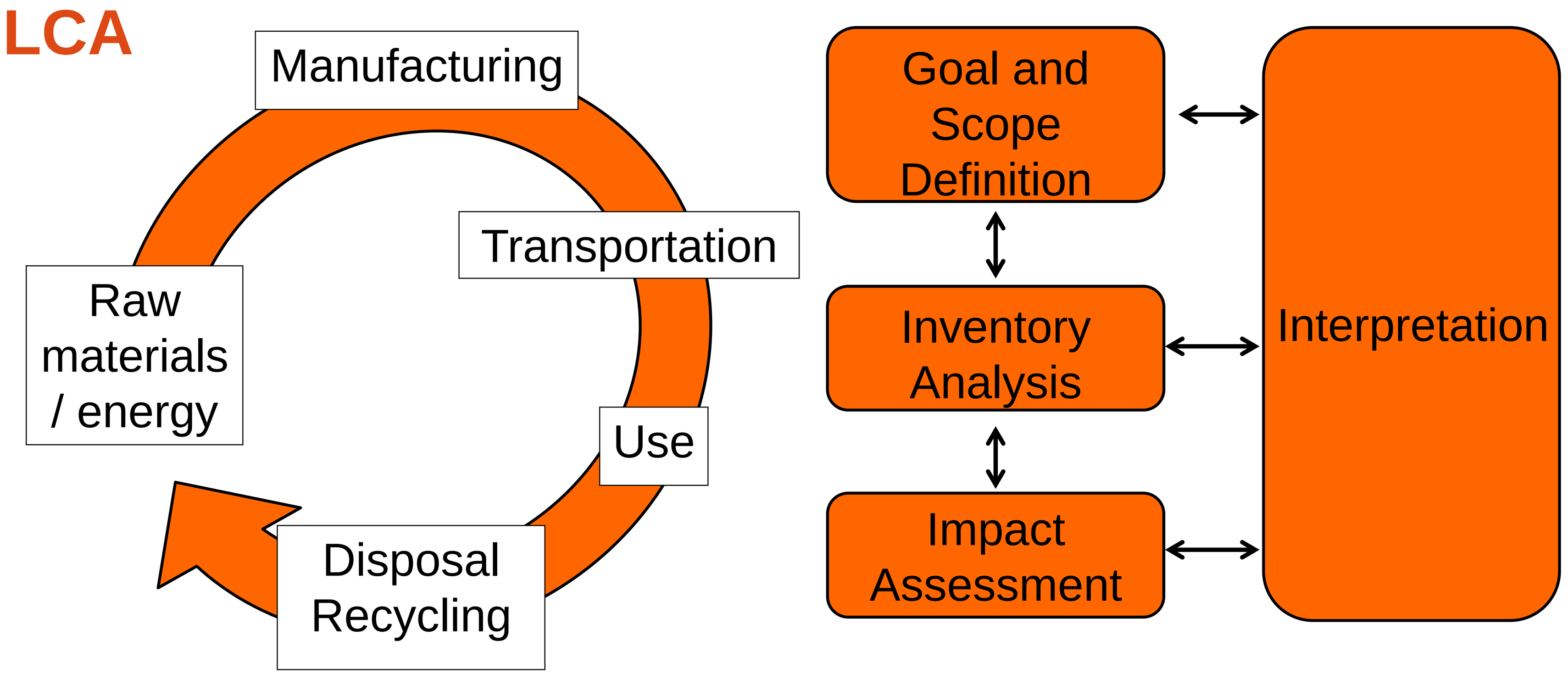
First generation Biofuel:
- Limit energy dependence
- High transformation losses
- Low yield
- Competition with food crops

Lignocellulosic biomass (second generation technologies)

Abundant, cheap, and available in non-food plants: wood and energy crops such as miscanthus.

Environmental impact ? LCA (Life Cycle Assessment)

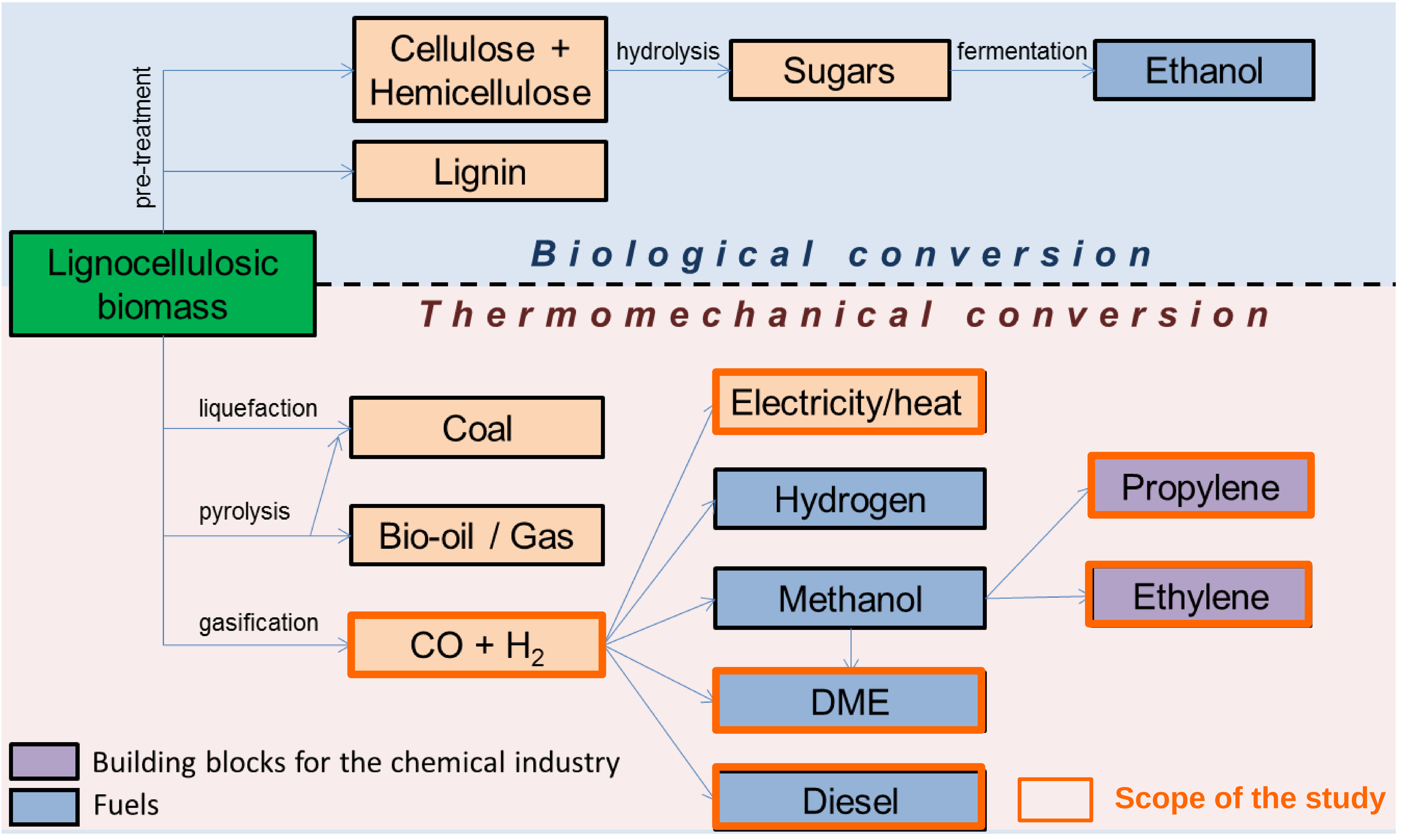
LCA



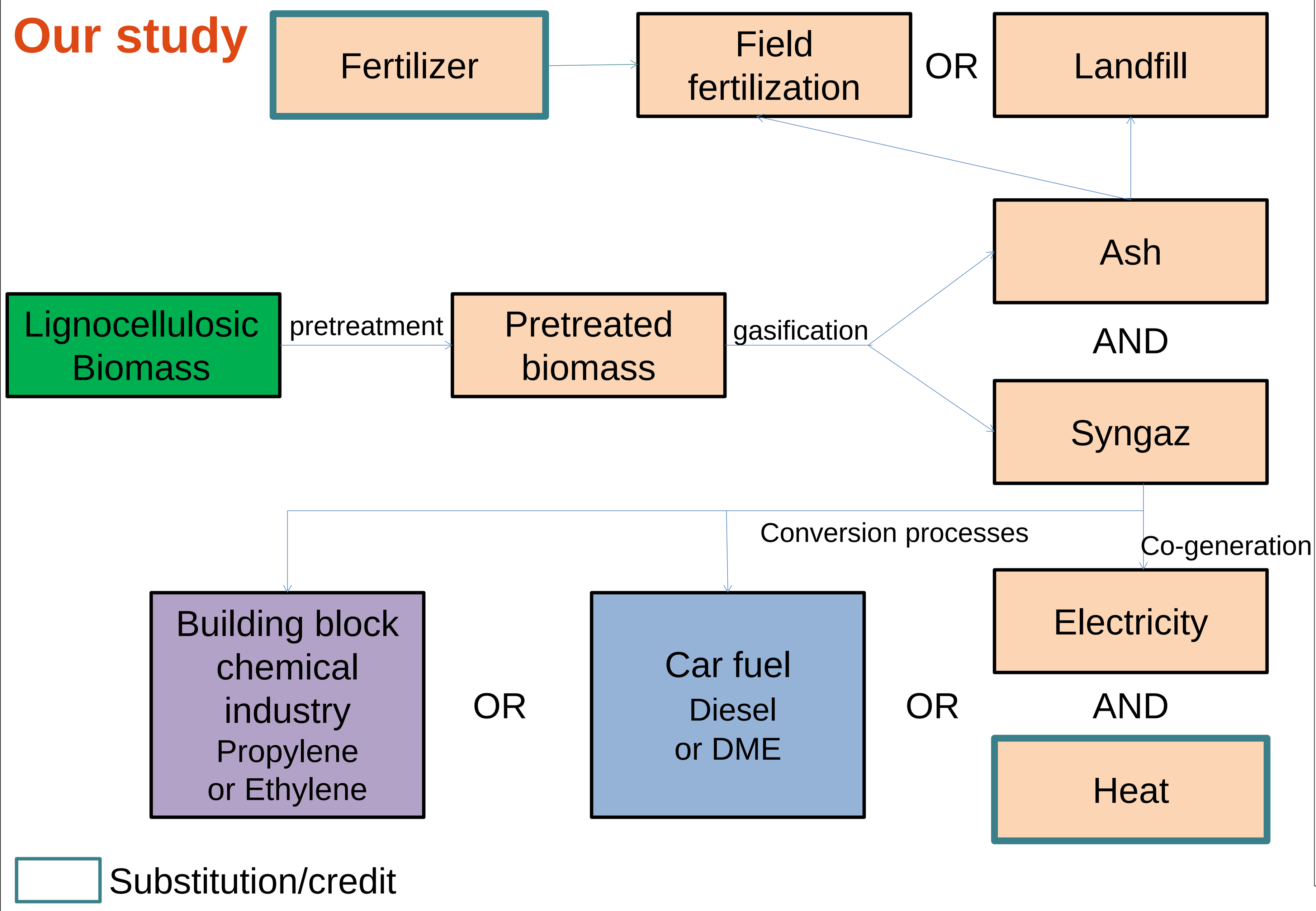
LCA: environmental aspects and potential impacts for all the stages of a product's life. Energy and material fluxes for the entire life-cycle analysed (environment / human health)

4 interdependent steps (ISO 14040 and 14044 norms [1,2])

Lignocellulosic biomass conversion processes



Our study



Process

Biomass pretreatment → Gasification → Gas cleaning and reforming → Gas use

Pretreatment

- **Size reduction**: particle size between 20 and 80 mm
- **Drying**: water content < 10%

Gasification

Biomass + Oxidizing agent → Syngaz

T= 600 – 1000 °C

Component	% (volume)
CO	31-40
H_2	33-36
CO_2	23-35
CH_4	2-3

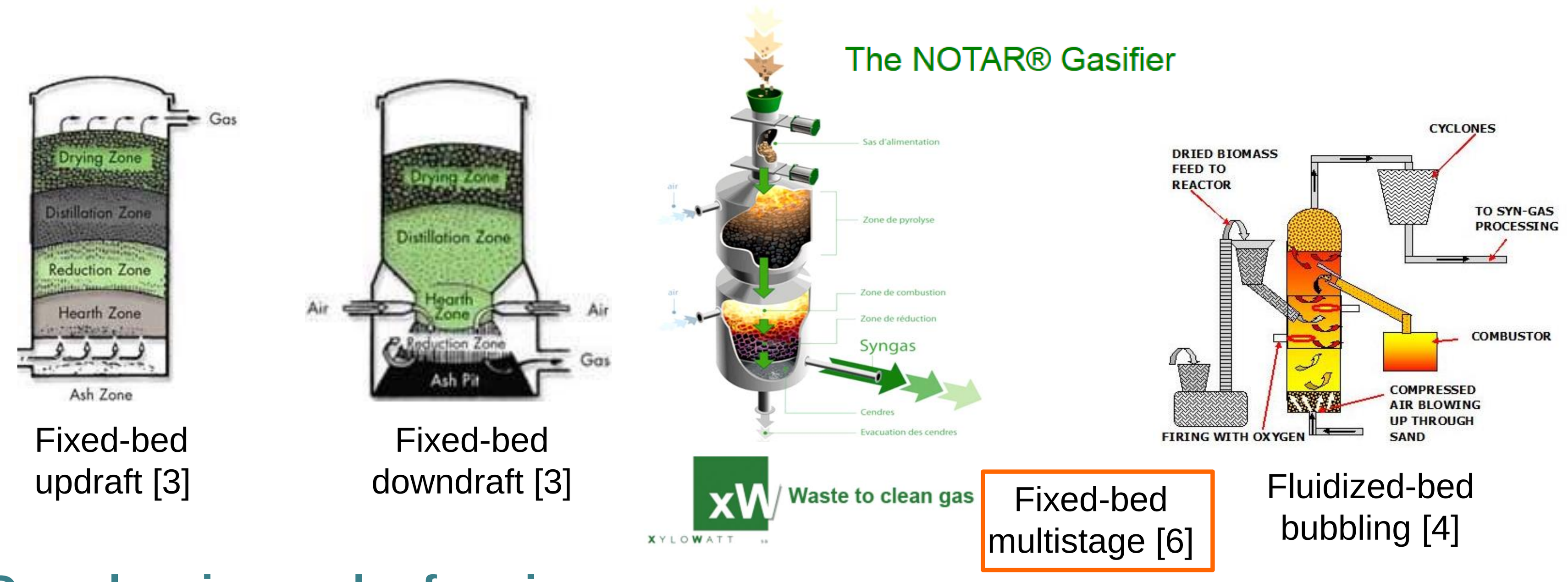
+ inertes

Oxidizing agent:
- Air
- Oxygen
- Steam

Heat supply:
- Allothermal or autothermal
- Direct or indirect

Scope of the study

Reactor type



Gas cleaning and reforming

Dependent on gas use

- **Particle removal**: biomass (ash and char)+ bed → plugging
- **Alkali removal**
- **Nitrogen** and **sulfur compounds**: small amount
- **Tar elimination**: primary (in gasifier) or secondary technologies
- **Reforming**: Water-shift reaction : $CO + H_2O \leftrightarrow CO_2 + H_2$ → H_2/CO

Downdraft, fixed-bed two-stage gasifier → Very low amounts of tar. This gasifier is generally considered to work close to the equilibrium state.

Ashes end of life → Presently, in the Belgian legislation context, the ashes must be landfilled but, in the future, it may possible to use them for field fertilization

Different gas uses are compared with their fossil equivalent.

Co-product: system expansion by substitution (avoiding allocation procedure): the avoid impact, due to the co-product is subtracted to the system impact.

Conclusions and perspectives:

Lignocellulosic biomass gasification: Promising processes for substituting fossil fuels (building blocks for the chemical industry and fuels).

Their environmental impact remains uncertain → LCA methodology needed

Numerous possibilities → sensitivity and uncertainity analysis.

Take into account the impact of biomass production.

LCA :
- Allows comparison bewteen biomass development and fossil technologies;
- Allows a better understanding of the environmental impact of the processes;
- Takes into account several impact categories.

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