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A systems approach for sustainable biorefineries

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Background

Refining of biomaterials is a relative young discipline that allows the replacement of non-renewable resources. In this developing field process design is focussed on combining technically feasible solutions, while sustainability of the solutions is typically assessed after the phase of process design (Figure 1). Better solutions will be obtained if sustainability is already included in an early design phase, whereby the selection of operations is simultaneously guided by technical, sustainability and economic criteria (Figure 2).

Biorefineries

In biorefineries biomass is used to produce a variety of food, feed, chemicals, materials, and fuels. The product mix depends on the biomass, on the value of the products, and on the sustainability impact of the overall system. Most well-known biorefineries feedstocks are maize, sugar cane and micro-algae.

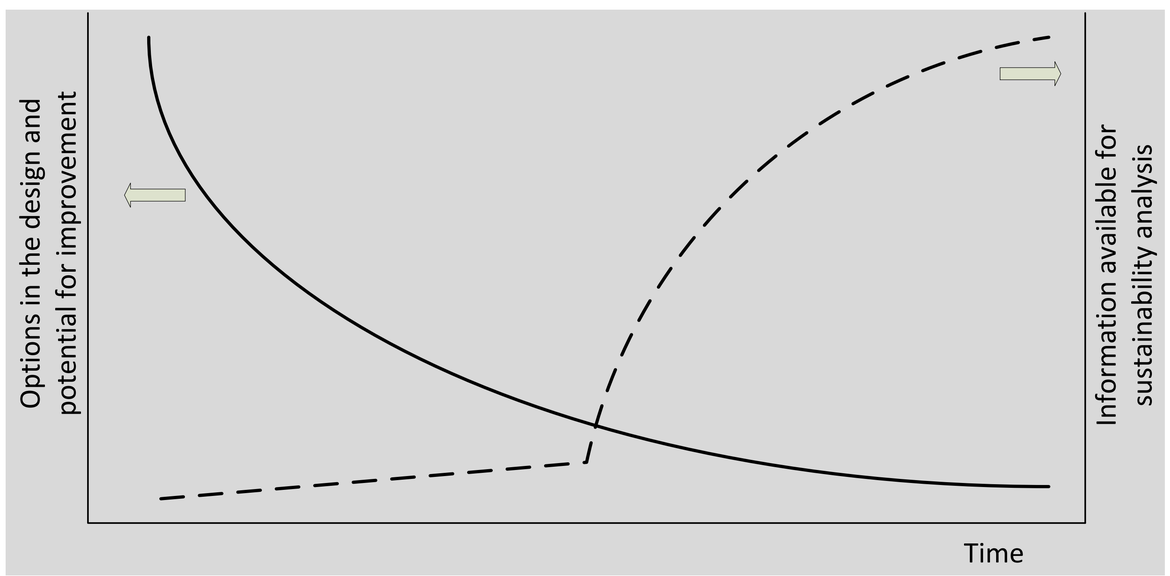

Figure 1. In early phases of design processes are more flexible and the system has more potential for improvement. Bottleneck is that at that time the knowledge level is still low.

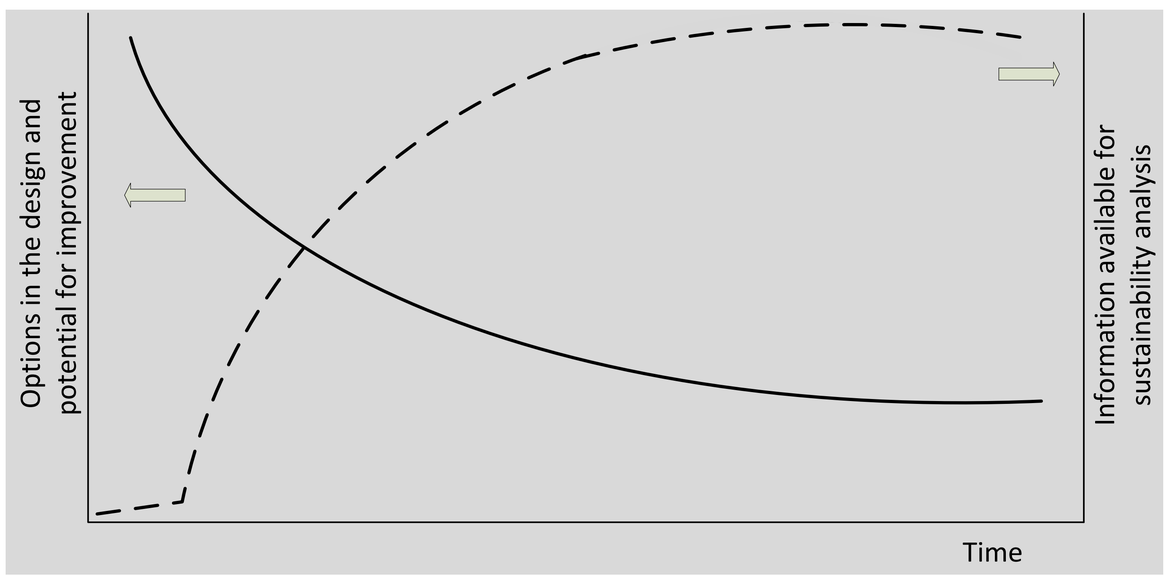

Figure 2. Suggested approach in which sustainability assessment is integrated during the development of technology and the processing chain design. This will give preliminary information on the sustainability performance and more flexibility in the design.

Ultimately, we aim for biorefinery designs that include sustainability in an early phase of design.

These will allow to 1) make a substantial contribution to sustainability through sustainable products, 2) being able to deal in design with changing requirements for sustainability, and 3) advice how to set the rules of the game for future sustainable production processes.

Objective On this poster we present a systems approach to unravel the connection between sustainability and process design.

Challenges to address

- Sustainability is a goal and tool at the same time
- Detailed information needed for evaluation, while during design typically only rough info available
- Little is known on the expected trends in biorefinery performance between early phase and final design
- At the end of design, the system is not flexible and cannot be changed to new policy demands
- Connection between biorefinery design and sustainability performance is poorly understood

Suggested approach

In the approach (Figure 2) methods from process design, sustainability analysis, and systems analysis are combined. We suggest 3 steps:

Step 1: Assessing the sustainability impact of several well-developed biorefineries (sugar beet, potato, and coffee berries).

Why? To determine the most influential design elements and sustainability impacts.

How?
- Sustainability impact assessment
- Monte-Carlo simulations
- Ranking of results based on uncertainty ranges.

Step 2: Reduction of the sustainability assessment on simplified biorefinery designs.

Why? To confirm which design elements and performance indicators are most important.

How?
- Systematic elimination of design elements and parameters
- Systematic elimination of sustainability indicators

Step 3: The insights from steps 1 & 2 are applied to a new biorefinery design with microalgae as feedstock.

Why? Proof-of-principle.

How?
- Early stage sustainability assessment
- Chain bottleneck analysis

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