Life Cycle Assessment of Second Generation Biofuels Production Using High-Gravity Hydrolysis and Fermentation

CHALMERS

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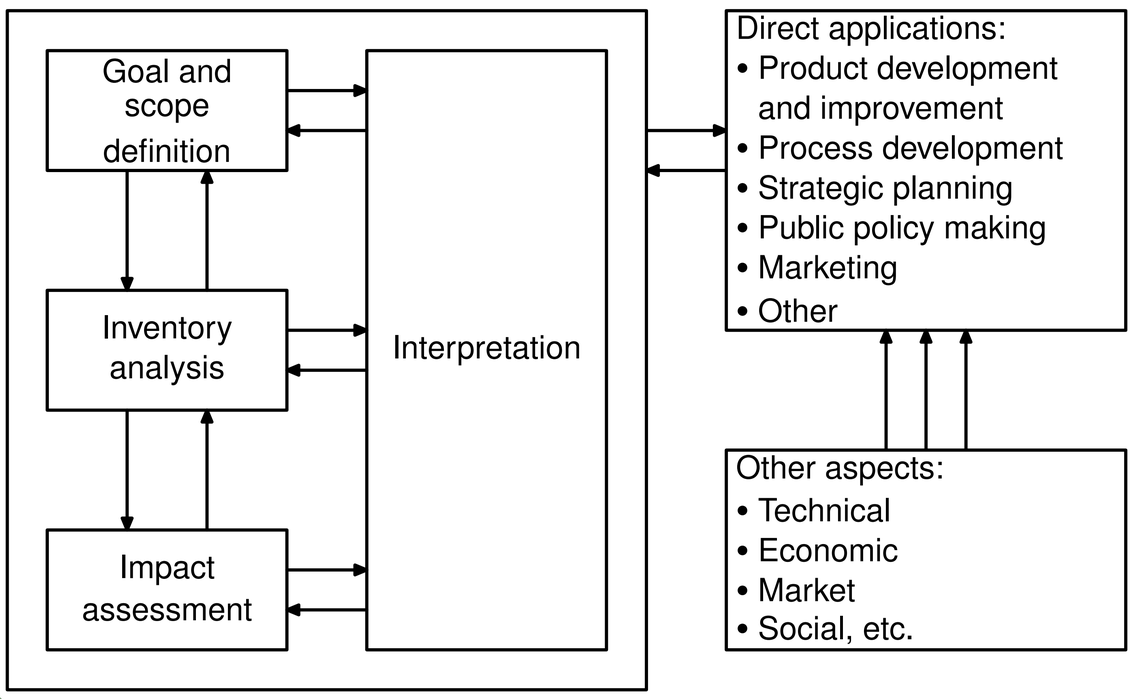
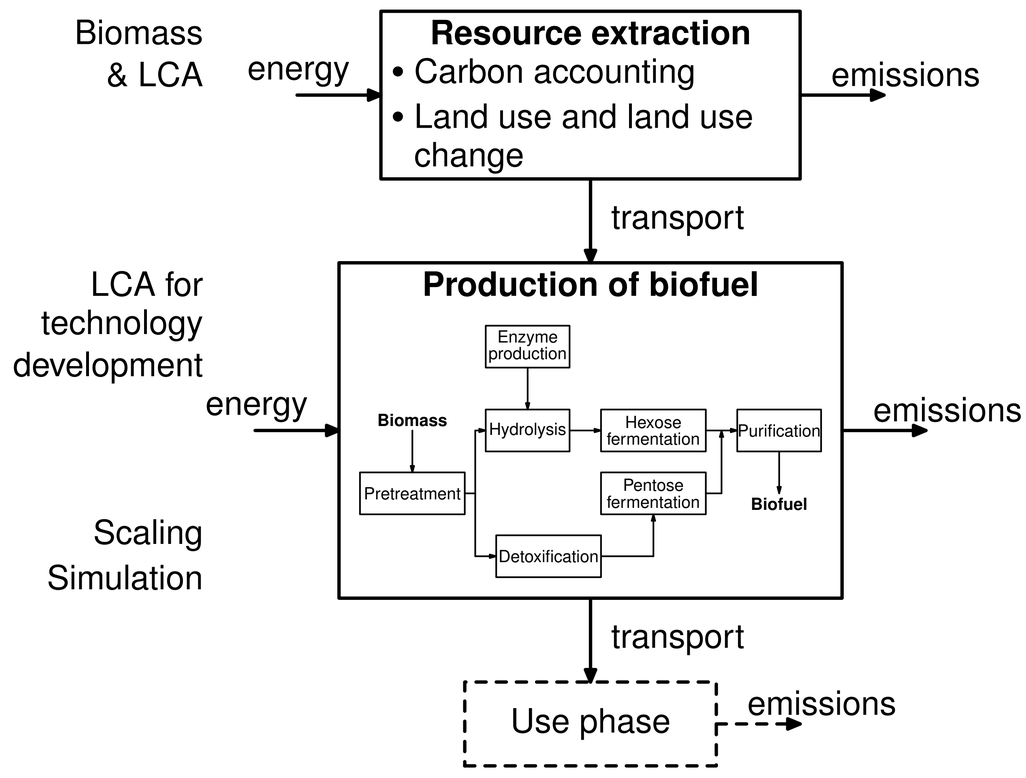
1. Introduction & research objectives

- Large interest in using bioethanol as transportation fuel
- Biobutanol as an alternative to bioethanol?
- Life cycle assessment (LCA) to determine the environmental performance of high-gravity technology for
  - Yeast-based ethanol production
  - Research steps to make butanol conceivable as a biofuel in addition to ethanol
- Simulation to accurately take into account scale up effects, at the process level and at the life cycle level
- Carbon accounting and (indirect) land use effects due to the production of 2nd generation biofuels

2. What is Life Cycle Assessment?



3. Biofuel production system



4. Issues raised by the case

1. **Biofuels and LCA**
   - Land use and indirect land use effects
   - Carbon accounting
2. **Technology development, scale and LCA**
   - Development "stages" with respect to system boundaries and scale[1]
     (a) Process step → Scale-up of equipment
     (b) Process complex → Optimization
     (c) Value chain → Inclusion of the upstream and downstream processes
   - Time and scale in technology LCA[2]
     - The relevant state is problem- and technology-dependent
     - Some methodological implications
       * Shifting time frame → Technical development, affects performance data, perhaps functional unit
       * Change in background system related to time and scale of technology penetration
       * Feedstock availability and production of by-products
3. **Simulation and LCA**
   - Simulation for calculating mass and energy flows, designing equipment, coping with the nonlinear nature of processes and quantifying uncertainty
   - Methodological frameworks usung simulation and LCA
     - Life cycle model for predicting economic cost, product and environmental performance[3]
     - LCA and process simulation under uncertainty[4]
4. **Use of the analysis results**
   - Suggest research steps for improvement/optimization of the fermentation process and the value chain
   - Decision support on how to proceed with development

5. Potential contributions

- Method for using LCA during the development of a technology
- Incorporation of scale effects at the process and life cycle level
- Incorporation of carbon accounting and land use (change) impact in the LCA of biofuels
- LCA of high gravity fermentation for biofuels production

References

[1] M. Shibasaki and S. Albrecht. In: *Proceedings of European Congress of Chemical Engineering (ECCE-6)*. 2007, p. 5.

[2] K. M. Hillman and B. A. Sandén. *Int. J. Altern. Propul.* 2.1 (2008), pp. 1–12.

[3] K. Gäbel, P. Forsberg and A.-M. Tillman. *J. Cleaner Prod.* 12.1 (2004), pp. 77–93.

[4] A. D. Bojarski et al. *Ind. Eng. Chem. Res.* 47.21 (2008), pp. 8286–8300.

HIGH GRAVITY Biofuels