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?

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<td>Other aspects:</td>
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<td>• Social, etc.</td>
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3. Biofuel production system

- Biomass & LCA
  - Energy
  - Carbon accounting
  - Land use and land use change
  - Resource extraction
  - Transport
  - Emissions

- Production of biofuel
  - Biowaste
  - Pretreatment
  - Detoxification
  - Hydrolysis
  - Enzyme production
  - Hexose fermentation
  - Pentose fermentation
  - Purification
  - Biofuel
  - Transport
  - Emissions

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
  - Process step → Scale-up of equipment
  - Process complex → Optimization
  - Value chain → Inclusion of the upstream and downstream processes
- Time and scale in technology LCA
  - 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 using simulation and LCA
  - Life cycle model for predicting economic cost, product and environmental performance
  - LCA and process simulation under uncertainty

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