Life Cycle Analysis of Food Waste Valorization in Laboratory-Scale

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Outlook of the presentation

- Introduction
- Goal and scope of research
- Methodology
- Results
- Conclusions
Introduction

Share of European renewable ethanol from each feedstock type

(Source: ePURE, 2020)

Advanced Biofuel Sources in RED II

- Algae if cultivated on land in ponds or photobioreactors
- Biomass fraction of mixed municipal waste
- Biowaste from private households subject to separate collection
- Biomass fraction of industrial waste not fit for use in the food or feed chain
- Straw
- Animal manure and sewage sludge
- Palm oil mill effluent and empty palm fruit bunches
- Crude glycerin
- Bagasse
- Grape marc and wine lees
- Nut shells
- Husks
- Cobs cleaned of kernels of corn
- Biomass fraction of wastes and residues from forestry and forest-based industries
- Other non-food cellulosic material
- Other ligno-cellulosic material except saw logs and veneer logs
- Used cooking oil
- Some categories of animal fats
Continued

How much biorefineries are sustainable?
LCA studies are performed for:

- Measuring the sustainability of biofuels includes environmental, economic and social considerations (directly/indirectly)
- Managing feedstock resources, energy & materials, financial sources
- Assisting to design optimized processes & technologies
The aim of the study was to investigate the early-stage LCA for food waste conversion to bioethanol, biomethane and oil, split over different scenarios.
Methodology

- **Goal & scope:**
  - System boundary: Gate-Gate
  - Functional unit: 1 kg of restaurant food waste
  - Software: SimaPro 8.5.2
  - Avoided product approach was considered

- **Inventory analysis**
  - Foreground data: laboratory experiments
  - Background data: Literature & Ecoinvent database

- **Impact assessment**
  - Assessment method: IMPACT 2002+
  - 9 mid point categories selected

- **Interpretation**
  - Characterization
  - Normalization, using European normalization references
  - Single score LCA results
  - Sensitivity analysis
System boundary for food waste valorization in scenario A & B
Results

Characterization results

- Electricity supply and VFA-rich effluent have paramount contribution to all categories.

- Utilization of yeast (sacharomyces cerevisiae), enzyme and n-hexane have the most undesirable effect on NRE, TE and AE, respectively.
Avoided burdens in dehydration, fat extraction and distillation processes

Avoided burdens in scenario A

Avoided burdens in scenario B
Normalization and Single score

Normalized potential impacts of scenario A and B, IMPACT 2002+

Single score LCA result for scenario A and B
Sensitivity analysis

Solvent type in fat extraction process

Enzyme loading in hydrolysis process

- n-Hexane
- Methanol
Conclusions

- Electricity production, VFAs, enzyme, yeast and n-hexane are contributing mainly to environmental burdens in all impact categories.

- Since the number of direct burdens was greater than the avoided burdens, the impacts were not fully avoided but reduced.

- Resource depletion is a result of extracting raw material and fossil fuels for energy, organic solvent, yeast and enzyme production.
The high environmental damage in the climate change category is attributed to the emission of CO2 from electricity and nutrient/chemical production.

The optimum amount for enzyme loading and n-hexane application are the best options to improve environmental performance along with process efficiency.

An early stage LCA can inspire changes to design and improve the processes in the bioethanol industry.
Thank you!

Welcome to comments; angili@agh.edu.pl