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Life Cycle Analysis of Food Waste Valorization in Laboratory-Scale

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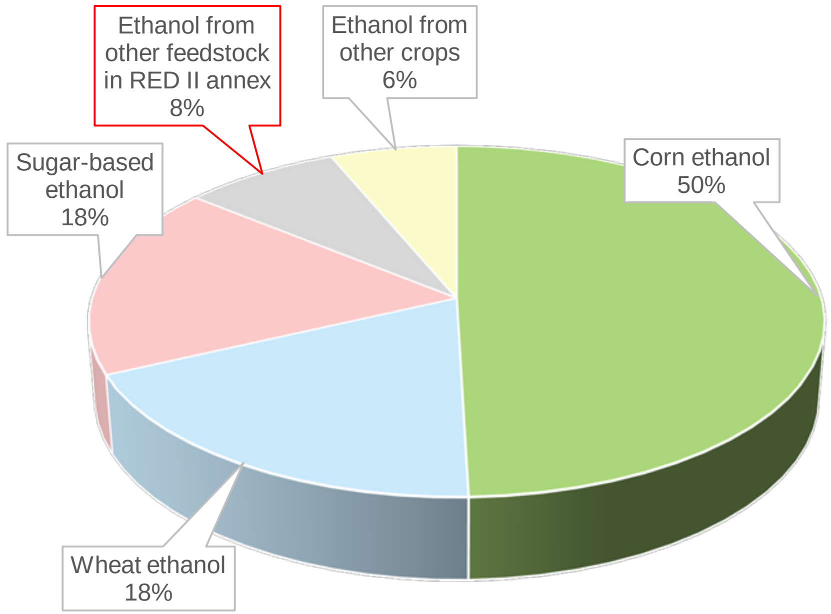
Outlook of the presentation

- 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 marcs 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

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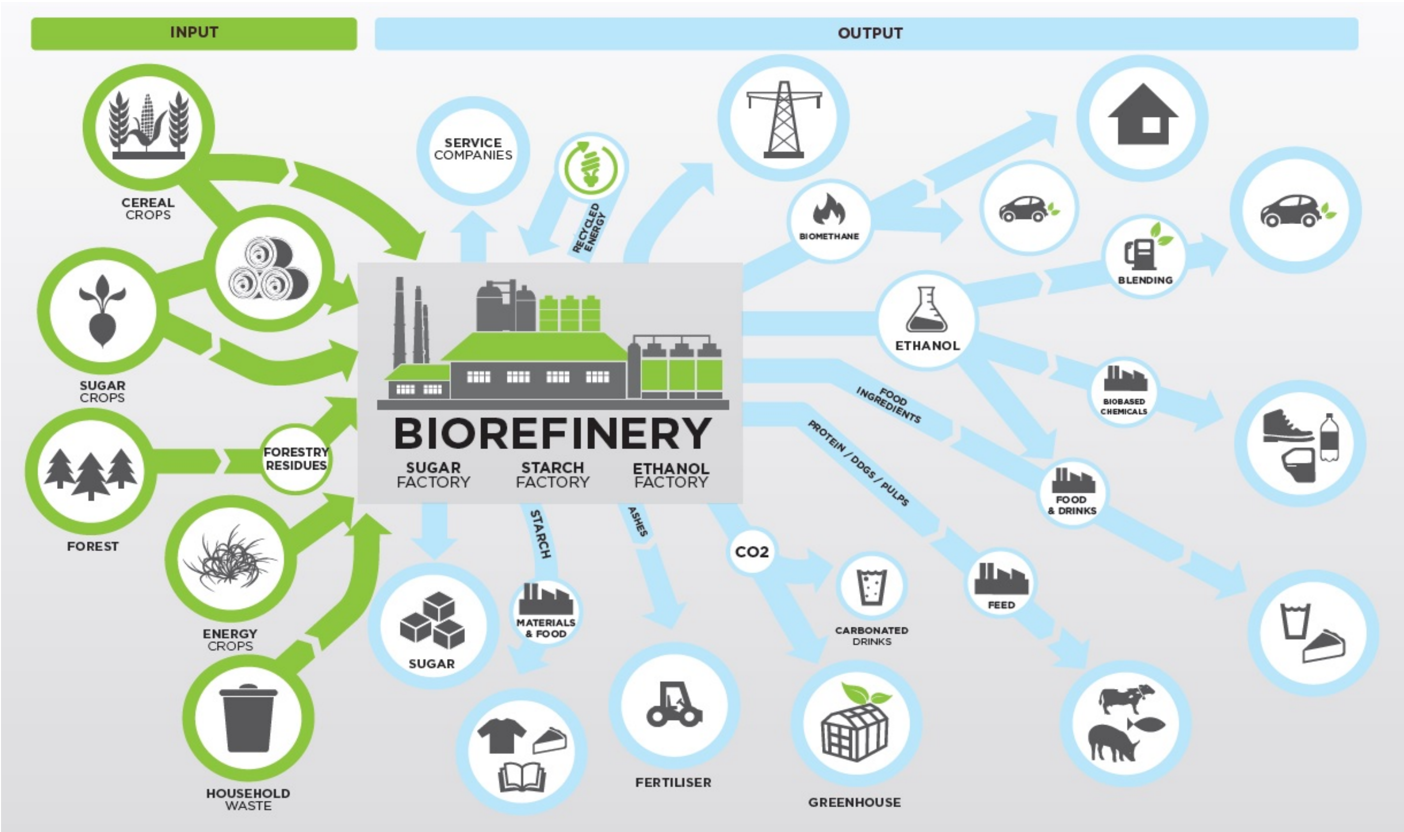
How much biorefineries are sustainable ?



(Source: ePure)

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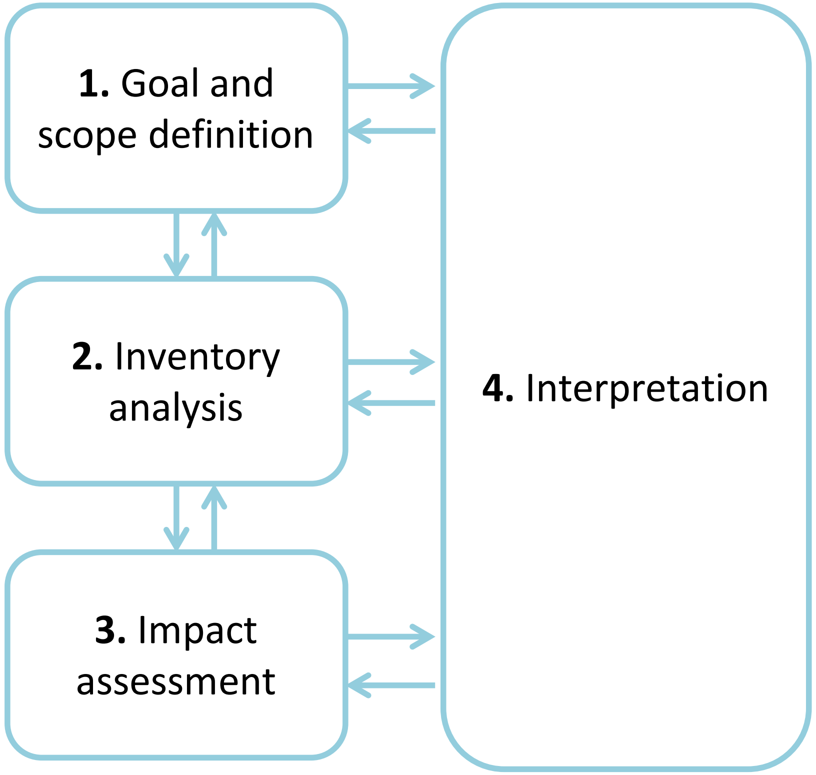


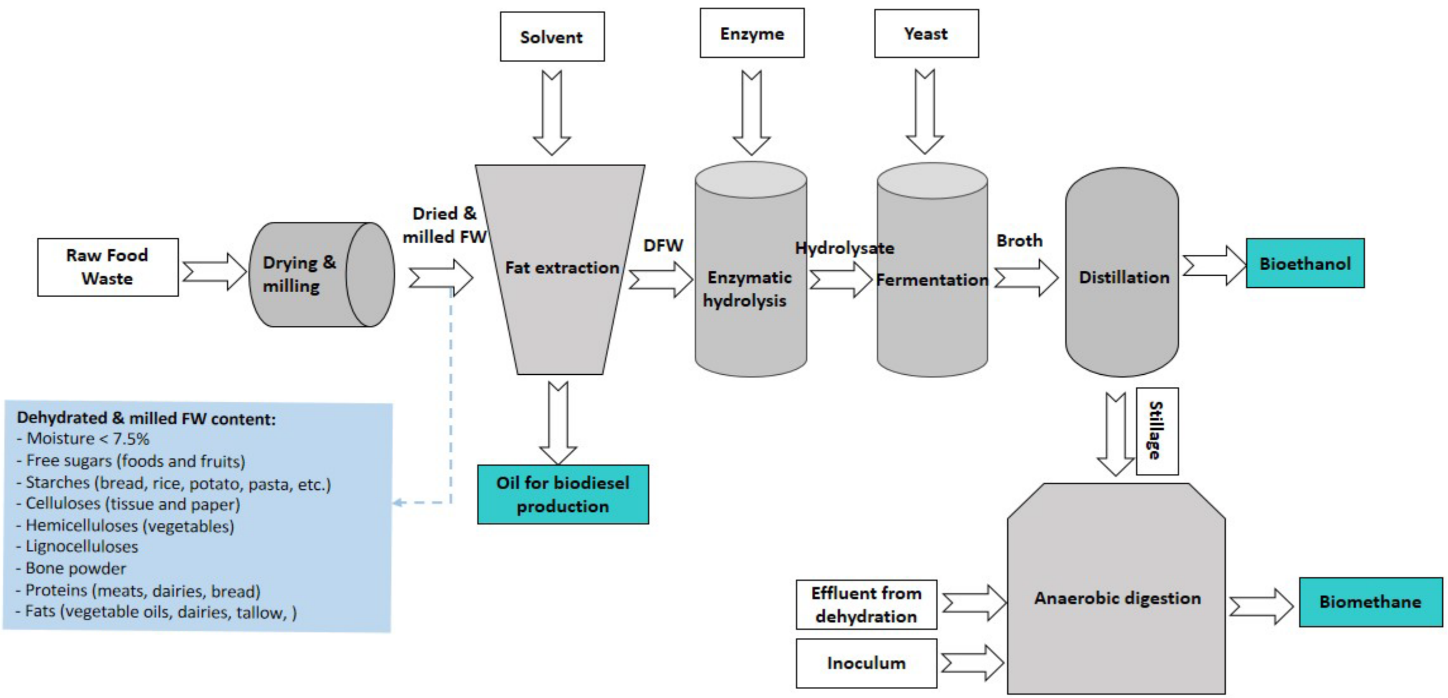
ISO 14040:2006(E)

LCA studies are performed for:

- ✓ Measuring the sustainability of biofuels includes **environmental, economic** and **social** considerations (directly/indirectly)
- ✓ Managing feedstock recourses, energy & martials, financial sources
- ✓ Assisting to design optimized processes & technologies

Goal and scope of research

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

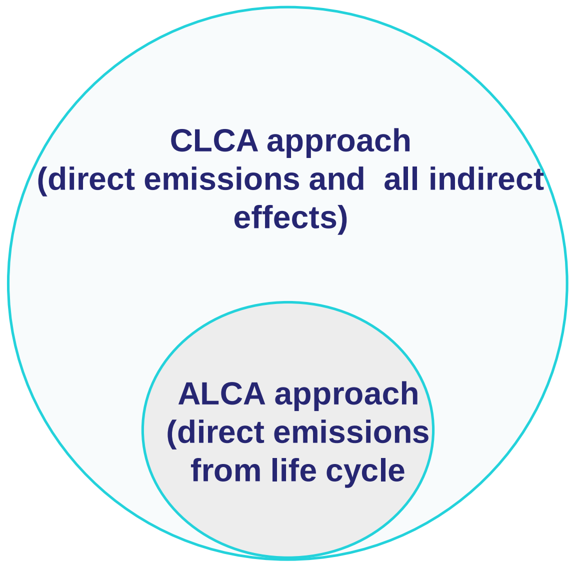
❖ **Impact assessment**

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

• Human health
• Ecosystem quality
• Climate change
• Resources

❖ **Interpretation**

- Characterization
- Normalization, using European normalization references
- Single score LCA results
- Sensitivity analysis



Impact category	Unit	Abbr.
Ozone layer depletion	kg CFC-11 into air-eq	OD
Respiratory (organics)	kg ethylene into air-eq	RO
Ionizing radiation	Bq Carbon-14 into air-eq	IR
Land occupation	m^2 organic arable land-eq.y	LO
Global warming	kg CO2 into air-eq	GW
Non-renewable energy	MJ crude oil-eq	NRE
Mineral extraction	in MJ Iron-eq	ME
Terrestrial ecotoxicity	kg Triethylene glycol into soil-eq	TE
Aquatic ecotoxicity	kg Triethylene glycol into water-eq	AE

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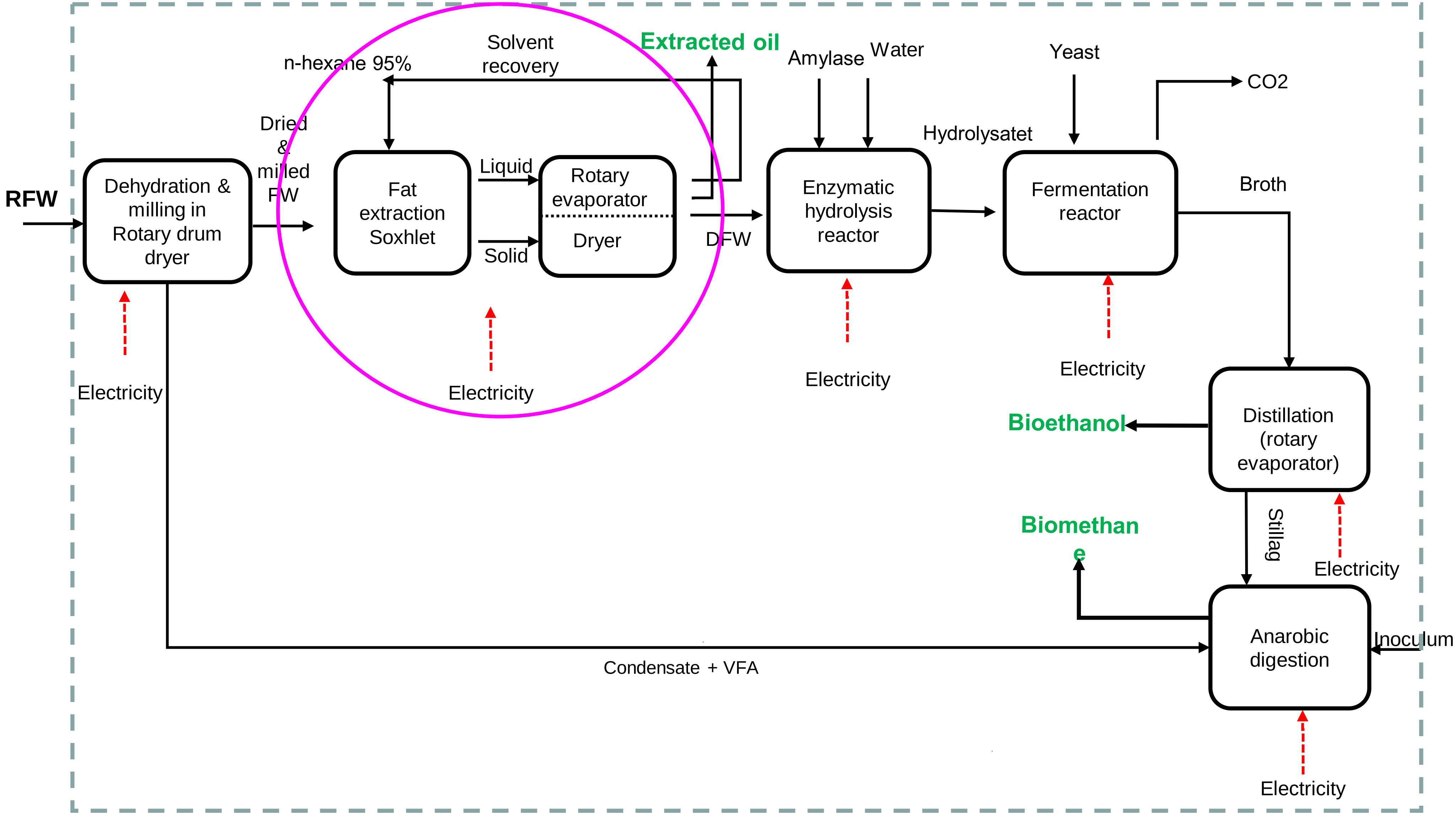
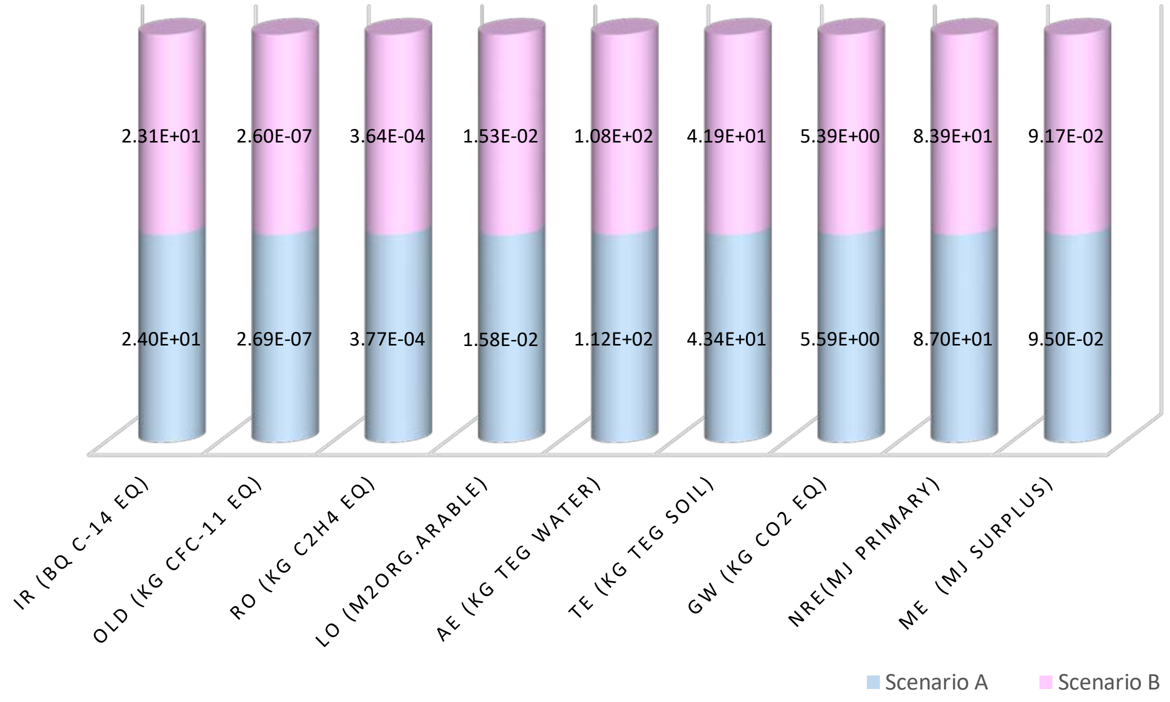


System boundary for food waste valorization in scenario A & B

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.

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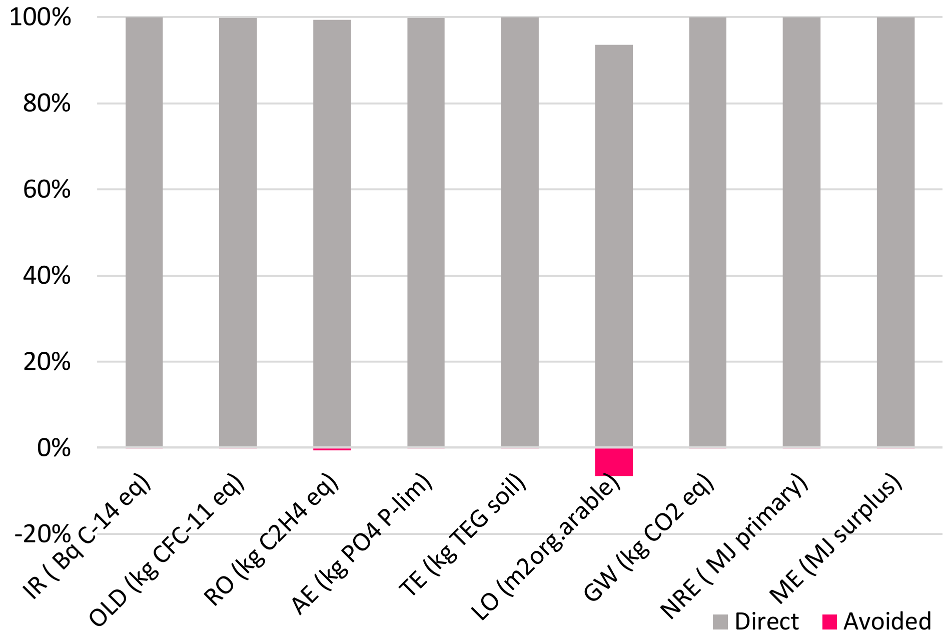
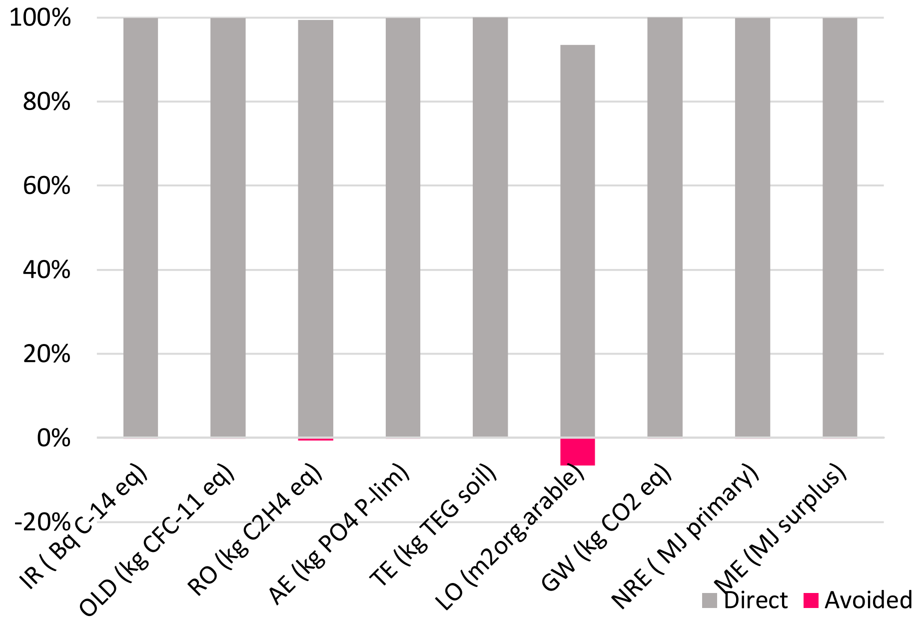
Avoided burdens in dehydration, fat extraction and distillation processes



Avoided burdens in scenario A



Avoided burdens in scenario B

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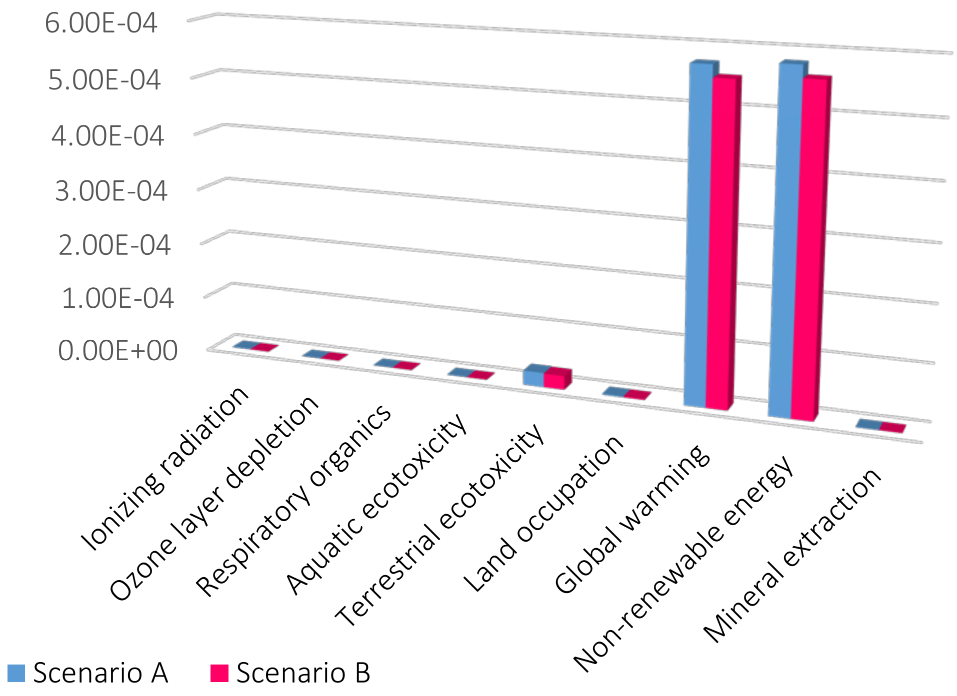
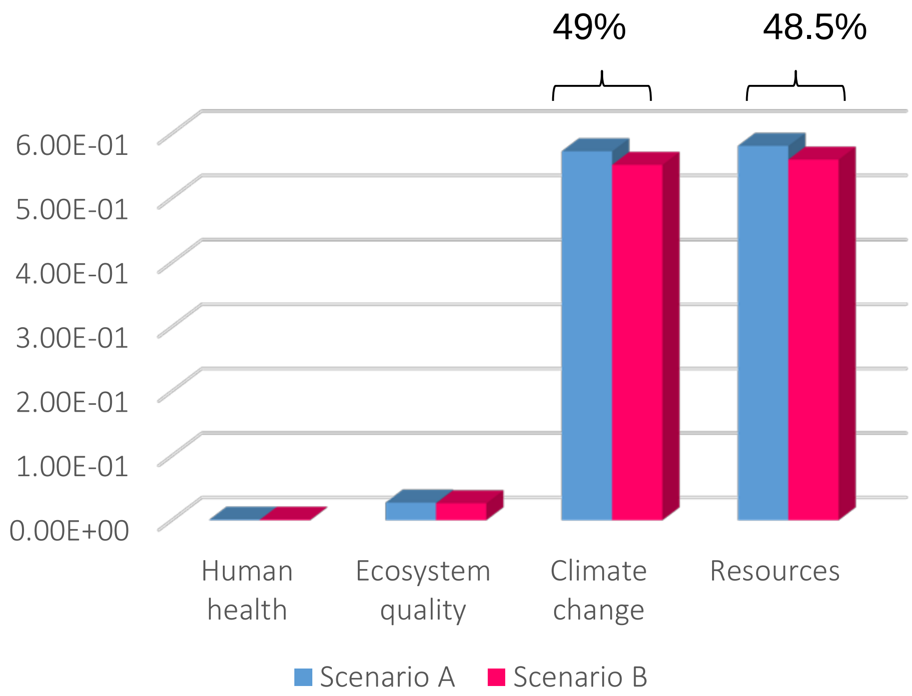
Normalization and Single score





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

Single score LCA result for scenario A and B

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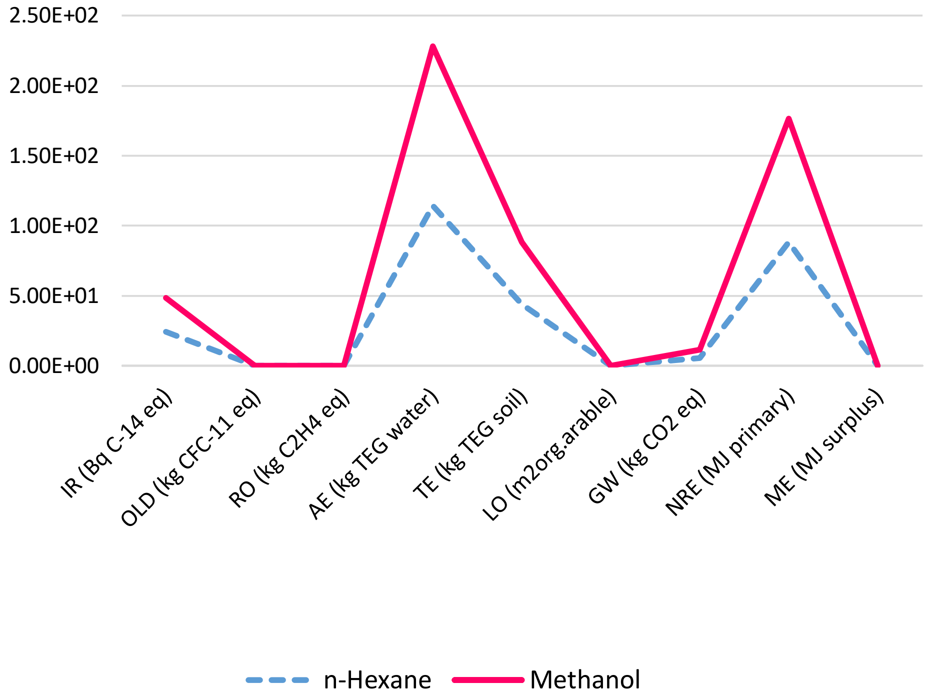
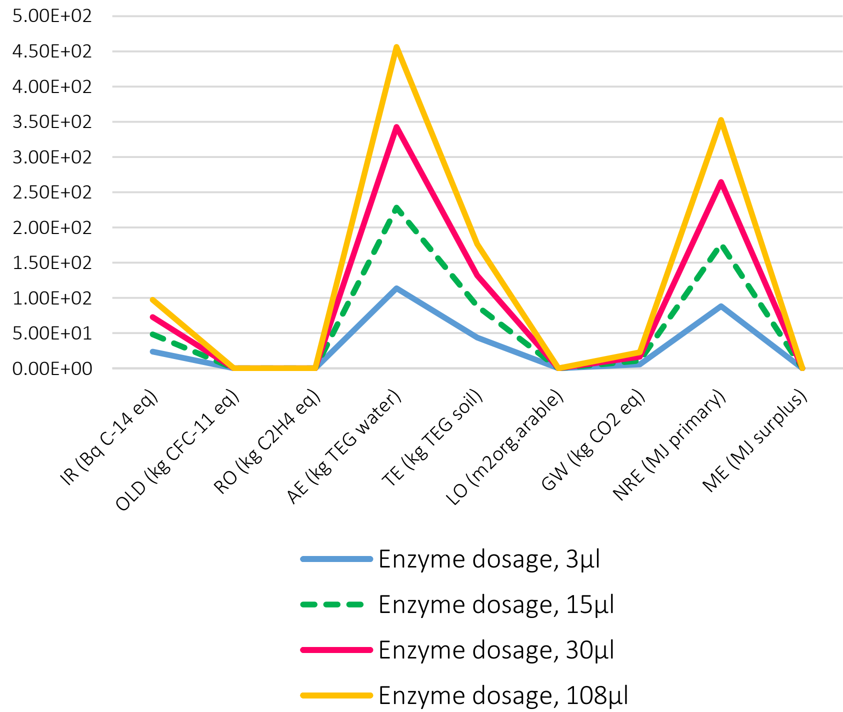
Sensitivity analysis

Solvent type in fat extraction process



Enzyme loading in hydrolysis process



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.

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- The high environmental damage in the climate change category is attributed to the emission of CO_2 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