1st BioSC Symposium: Towards an Integrated Bioeconomy
21.11.2016, Cologne, Germany

Biobased Processes: Systematically Evaluating Chances and Challenges

Andreas Pfennig
andreas.pfennig@ulg.ac.be
Products, Environment, and Processes (PEPs)
Department of Chemical Engineering
Université de Liège
www.chimapp.ulg.ac.be

PEPs CHEMICAL ENGINEERING

Université de Liège

possible biobased synthesis pathways

biomass

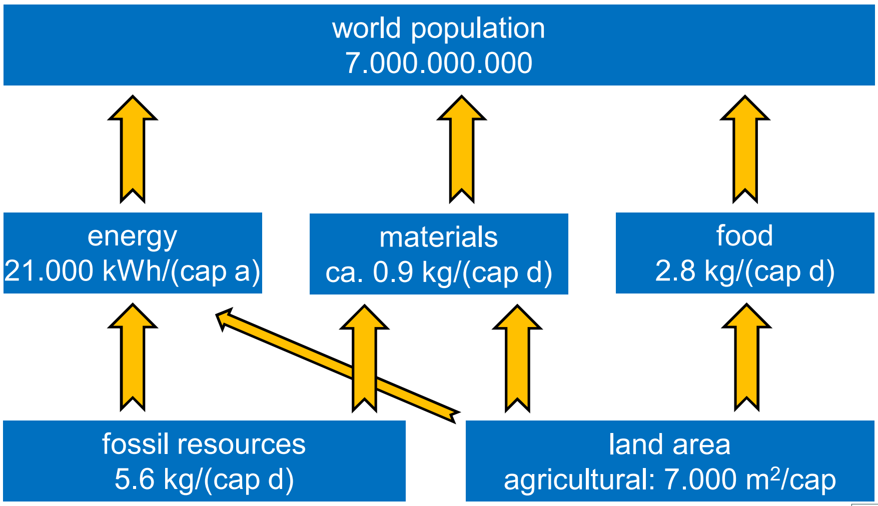
- gasification, pyrolysis: C1- (C2-, C3-) building blocks
- extract major components: starch, sugar, vegetable oil; remains: energy use
- separate „all“ components: cellulose, lignin, use of whole plant, biorefinery

products

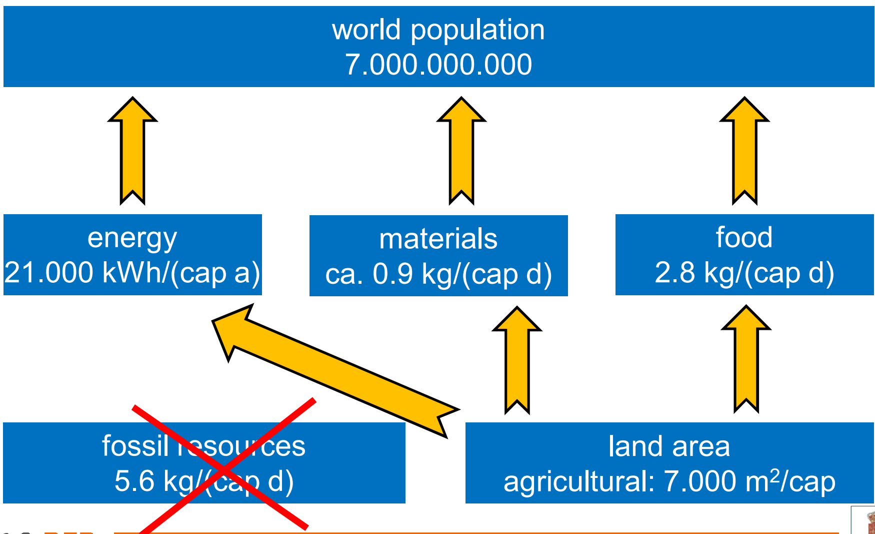
PEPs CHEMICAL ENGINEERING

Université de Liège

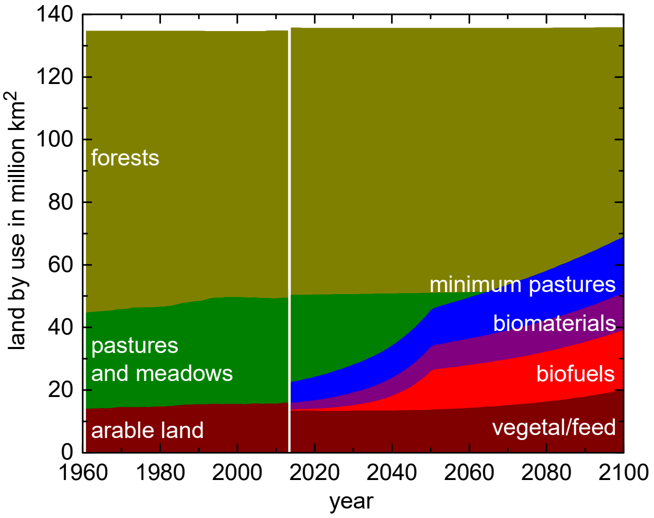
interaction of some major drivers



interaction of some major drivers



land-area use: +1.5°C, high pop. variant



in 2100:
CO_2 464 ppm
ΔT 1.50 °C

calculation of exergy

exergy of a material stream

$$E_i = \sum_{i=1}^{N} \left(E_{i,\mathrm{chem}} + E_{i,\mathrm{phys}} \right) + \Delta E_{\mathrm{mix}}$$

chemical exergy of a material stream

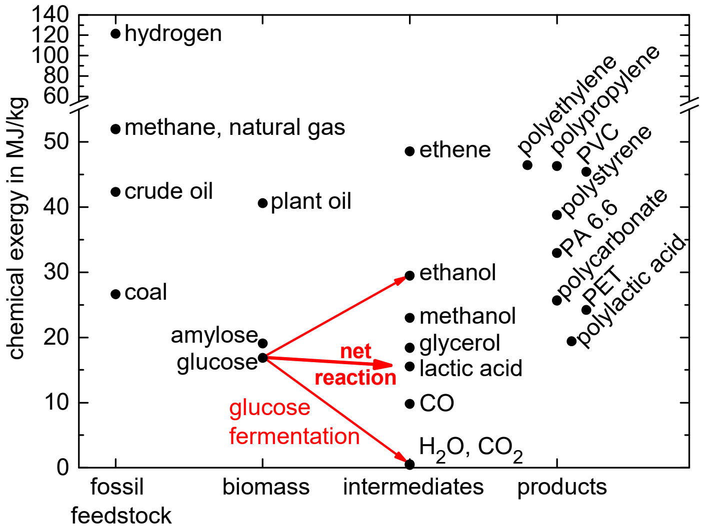
$$E_{i,\mathrm{chem}} = \Delta^{\mathrm{o}} G_i + \sum_{i=1}^{j} \nu_{i,j} E^{\mathrm{o}}_{j,\mathrm{chem}}$$

physical exergy of a material stream

$$E_{i,\mathrm{phys}} = \int_{T_\mathrm{U}}^{T_\mathrm{R}} C_i(T)\,dT + V_i^{\mathrm{iF}} (P_\mathrm{R} - P_\mathrm{U}) - T_\mathrm{U} \int_{T_\mathrm{U}}^{T_\mathrm{R}} \frac{1}{T} C_i(T)\,dT$$

+ exergy losses in processes and equipment

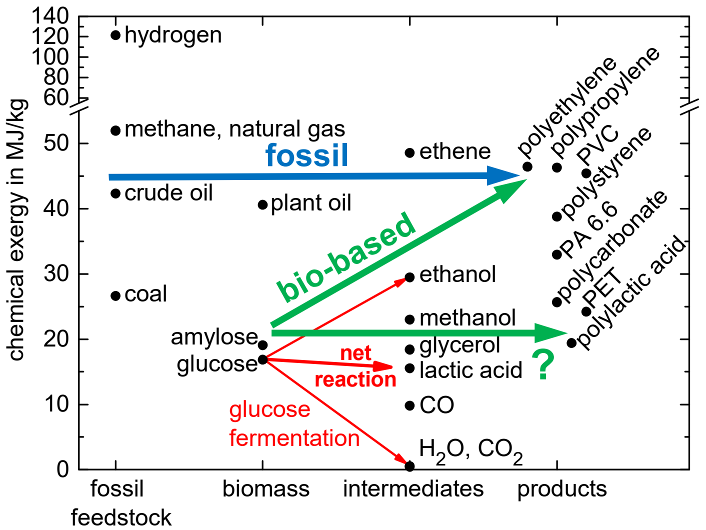
chemical exergy of various materials



PEPs CHEMICAL ENGINEERING

Université de Liège

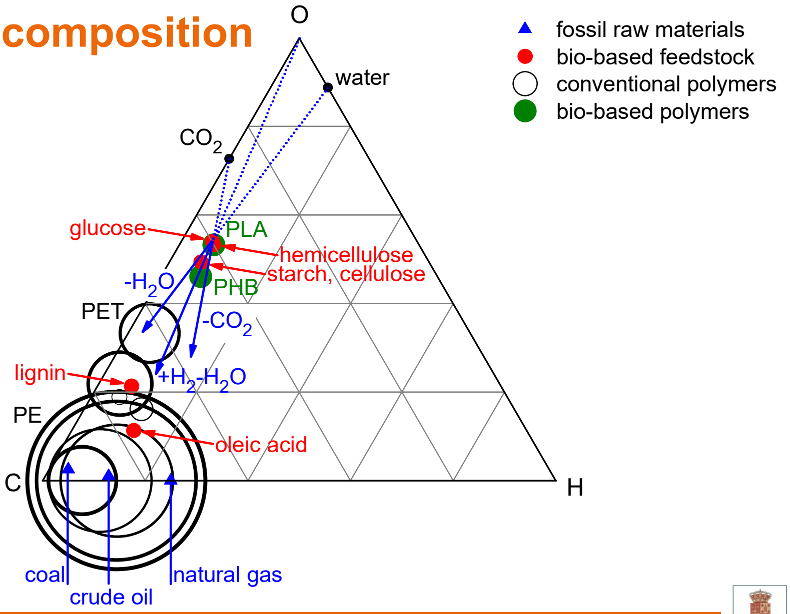
chemical exergy of various materials



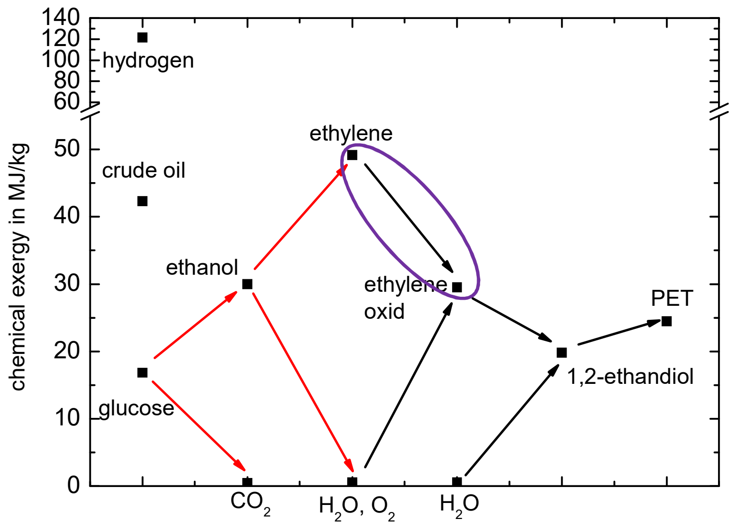
PEPs CHEMICAL ENGINEERING

Université de Liège

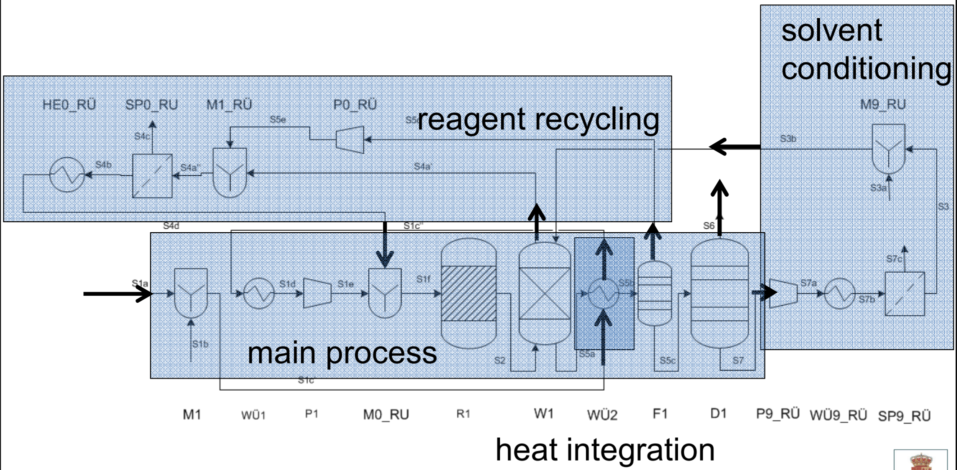
COH composition



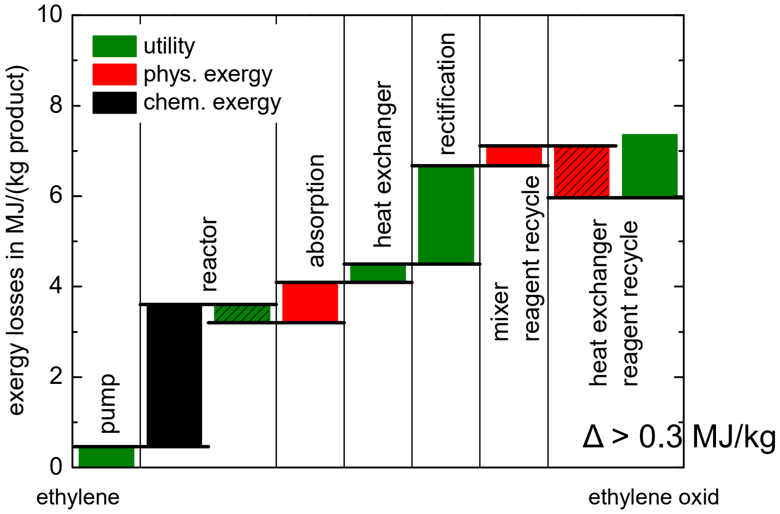
synthesis pathways to PET



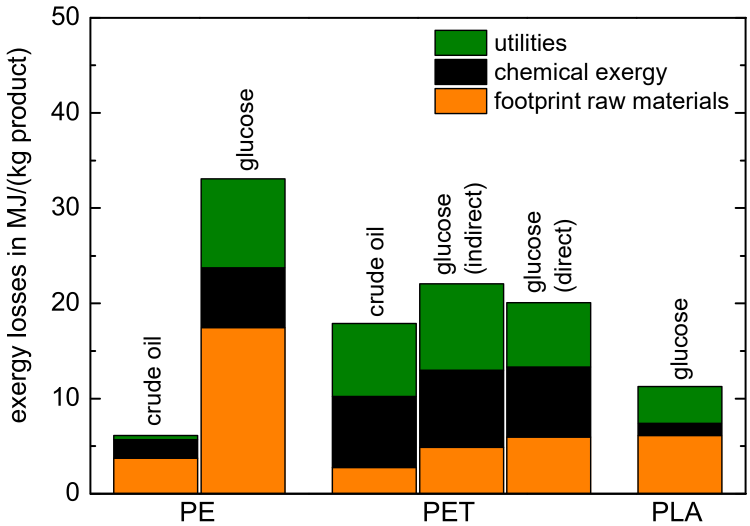
process: ethylene → ethylene oxid



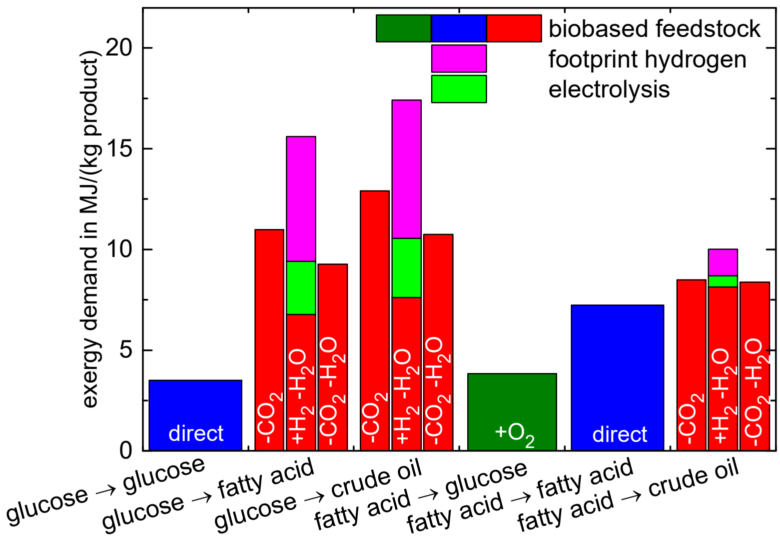
results of exergy analysis



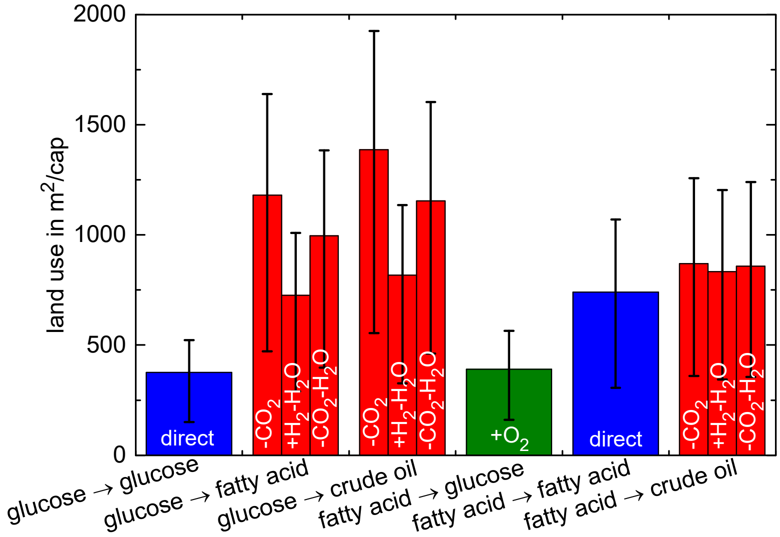
comparision of the processes



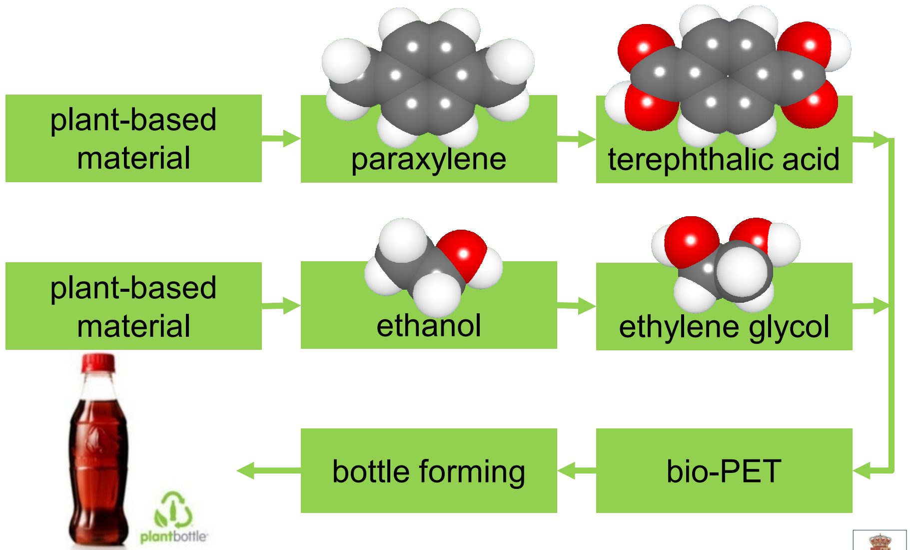
exergy demand for different routes



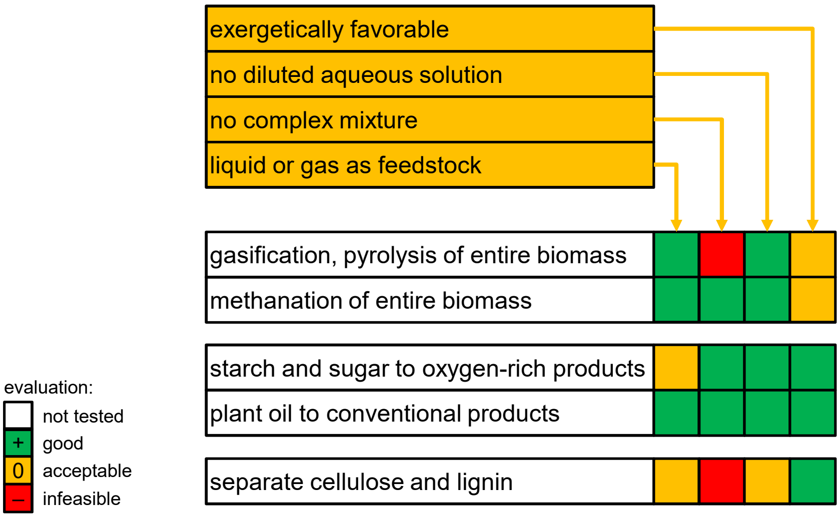
land-area use 2050 for different routes



process ideas



evaluation of selected options



evaluation of options

- exergy is general energy measure
- mix of feedstock and technologies
- results (integration limited):
  - extraction/separation of direct valuables
  - glucose $\rightarrow$ products with more oxygen
  - plant oil $\rightarrow$ products with less oxygen
  - rest to methanation
  - energy demand for processes will increase
  - land area required for biobased feedstock: 200 to 800 m^2/capita (food $\approx$ 7000 m^2/capita)
- integration:
  agriculture - production - consumer needs

references

P. Frenzel, S. Fayyaz, R. Hillerbrand, A. Pfennig:
Biomass as Feedstock in the Chemical Industry –
An Examination from an Exergetic Point of View
Chem. Eng. Technol. **36**(2) (2013) 233-240

P. Frenzel, R. Hillerbrand, A. Pfennig:
Increase in energy and land use by a bio-basedchemical industry
Chem. Eng. Res. Design **92** (2014) 2006-2015

P. Frenzel, R. Hillerbrand, A. Pfennig:
Exergetical Evaluation of Biobased Synthesis Pathways
Polymers **6** (2014) 327-345

Biobased Processes: Systematically Evaluating Chances and Challenges

Andreas Pfennig
andreas.pfennig@ulg.ac.be
Products, Environment, and Processes (PEPs)
Department of Chemical Engineering
Université de Liège
www.chimapp.ulg.ac.be