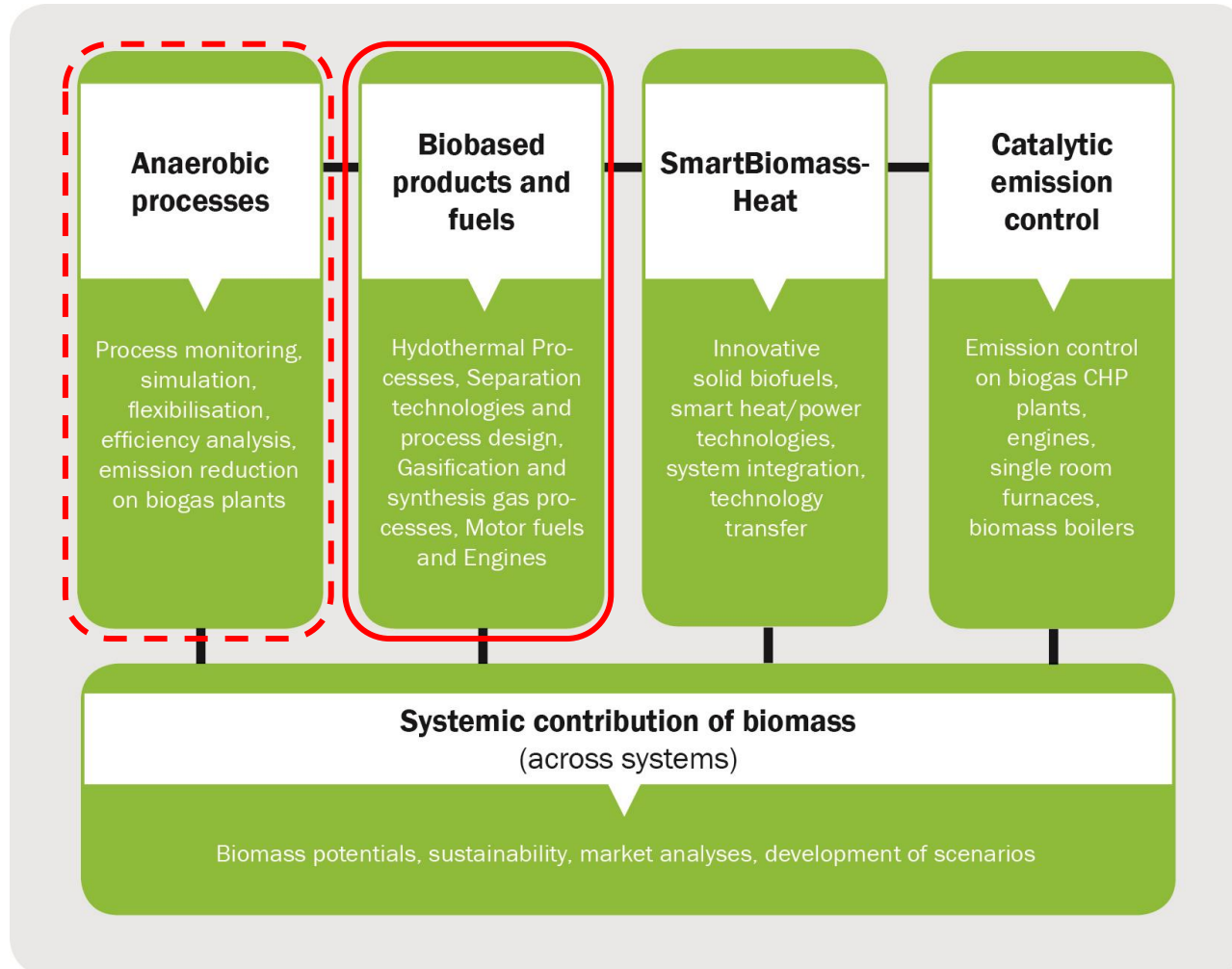


## Biorefineries – Biobased Products and Fuels

Exemplary R&D projects for the development of biorefineries

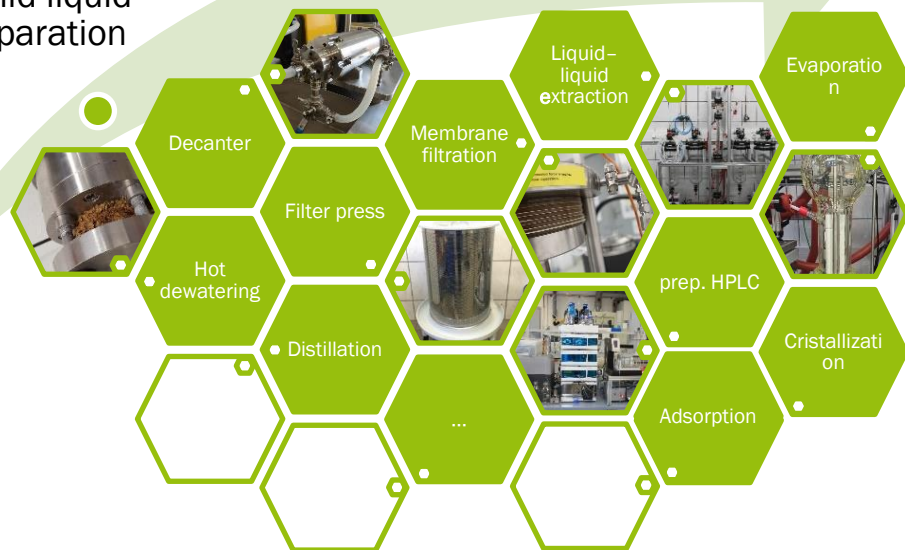
# The research focus areas at the DBFZ



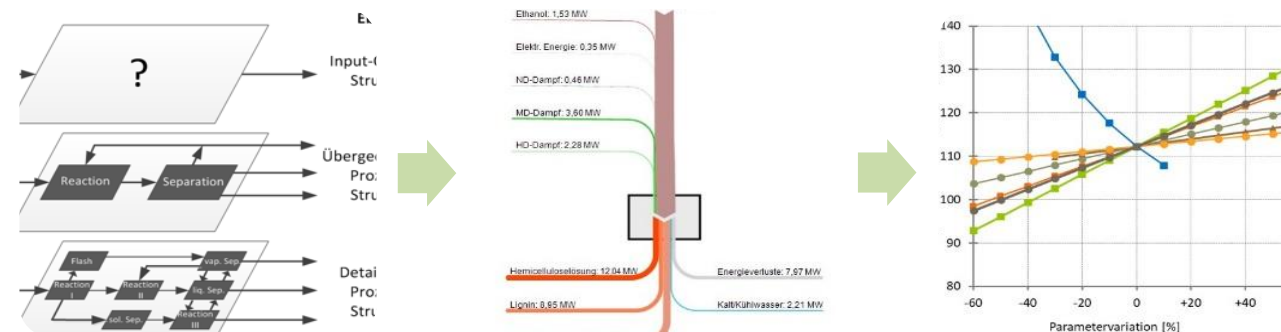
## Experimental methods

Solid-liquid separation

Liquid-liquid separation



## Biorefineries concepts und process simulation



### Conceptual design

- Process synthesis
- Upscaling
- Flow diagrams
- Logistics chains

### Process simulation

- Mass balance
- Energy balance
- Lists of equipments

### Techno - Economic Assessment

- TRL, CUA, ...
- Costs

## Strengths

- Attractive scale (1 - 100 kg/h) for downstream processes, which can be feasibly transformed to larger scales
- Expertise in the evaluation of biorefineries based on process simulations
- Synergies through the use of process simulations in the development of separation cascades

## Exemplary projects



**KomBiChem<sup>Pro</sup>**

**Wood based biorefinery**



**CapAcidy**

**Biorefinery based on anaerobic  
fermentation of wet biomass**



## Exemplary projects



**KomBiChem<sup>Pro</sup>**

**Wood based biorefinery**



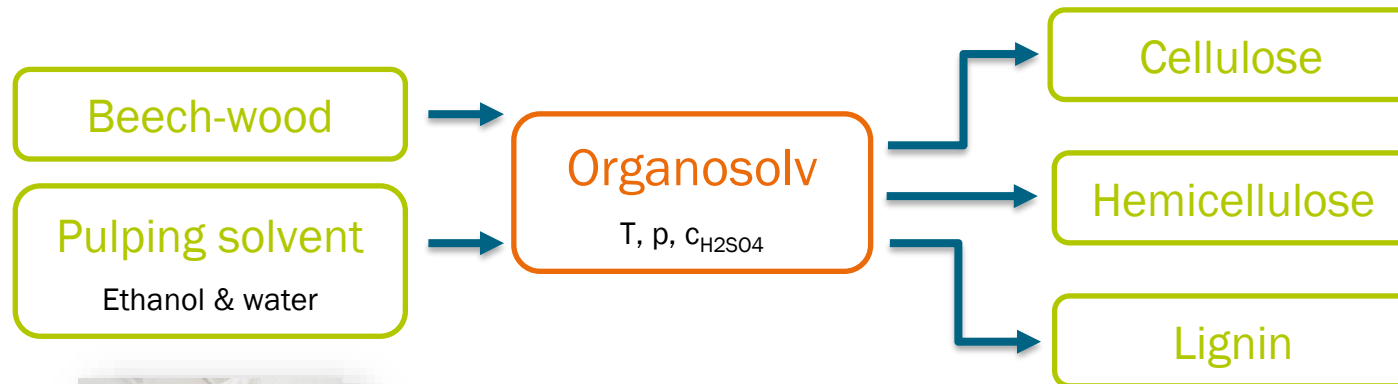
**CapAcidy**

**Biorefinery based on anaerobic  
fermentation of wet biomass**

# KomBiChem<sup>Pro</sup>

## Motivation and Aim

Basis for project: organosolv process @ Fraunhofer CBP



Aim of the KomBiChem project:  
**Development of fine and platform chemicals by a combination of chemical and biotechnological processes**

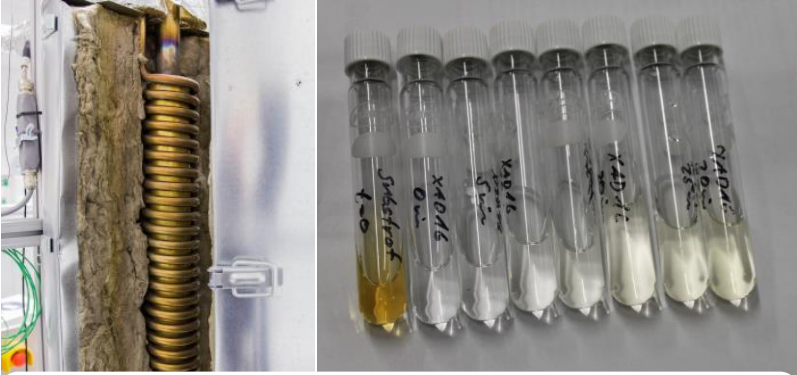
Products of interest

Dissolving pulp

C5-sugars, Xylonic acid, Malic acid  
Furfural, Furfuryl alcohol, THF  
5-HMF, Furandicarboxylic acid

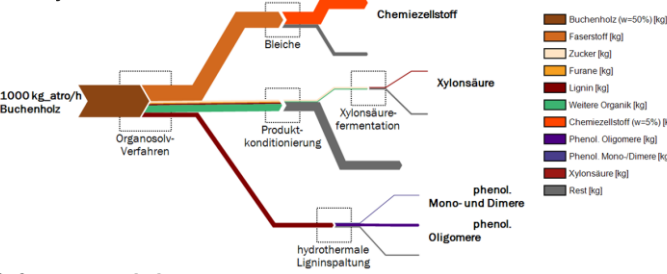
Phenols

# KomBiChem<sup>Pro</sup> Methods

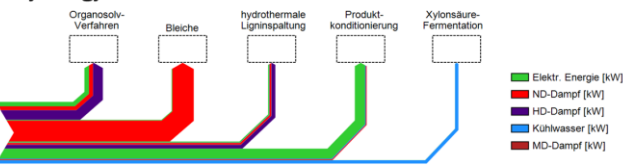


## 1. Lab scale development

Preliminary mass balance



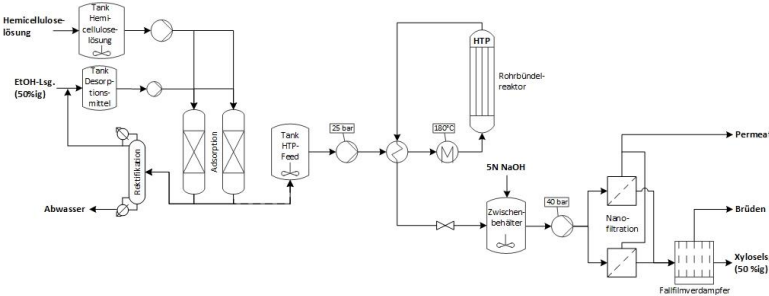
Preliminary energy balance



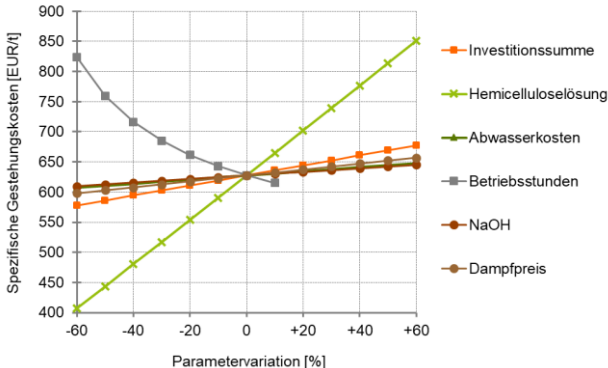
## 2. Early stage assessment



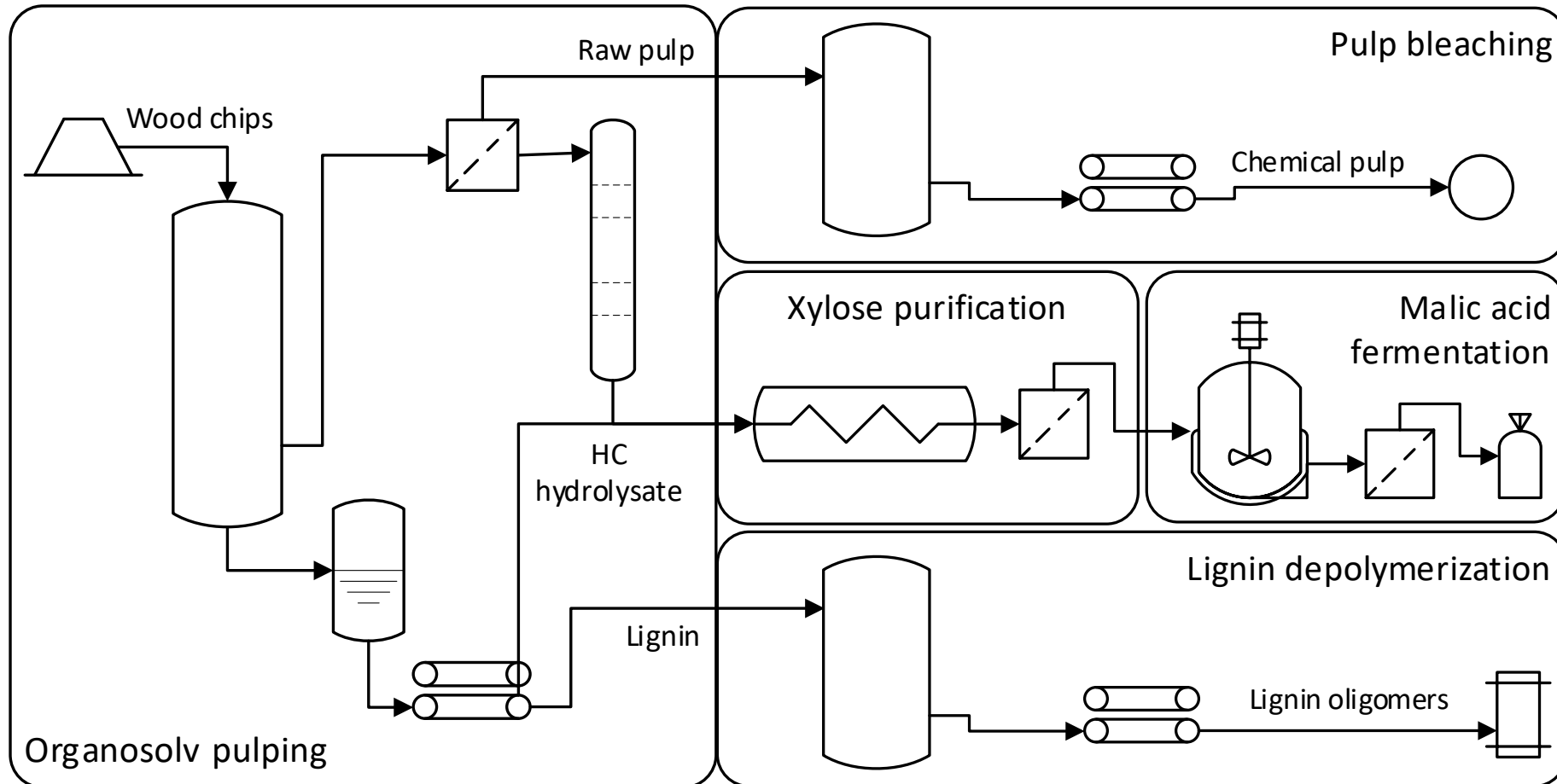
## 3. Transfer to pilot scale @Fraunhofer CBP



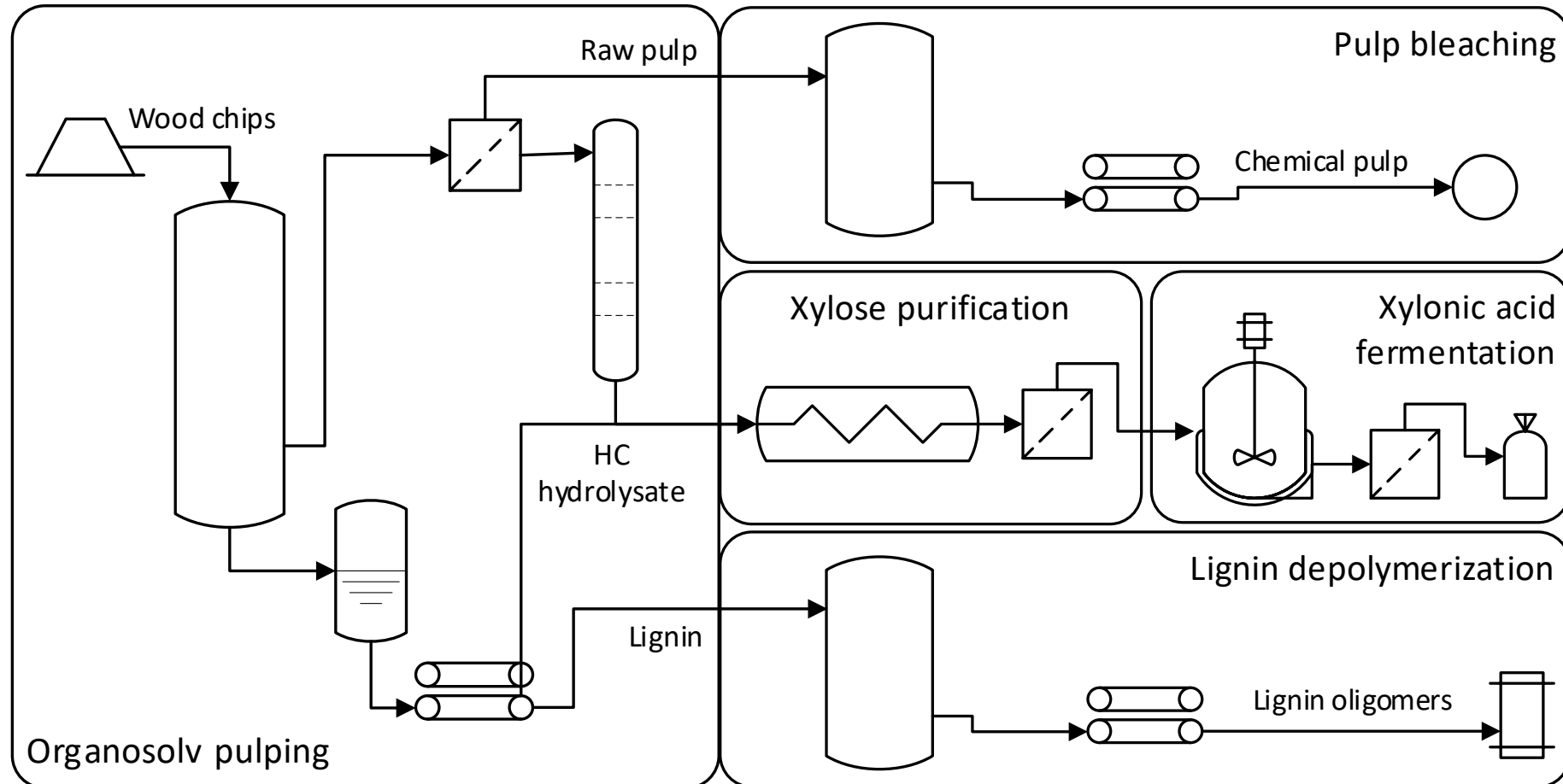
## 4. Concepts for implementation



## 5. Final assessment







**The conversion of beech wood into: dissolving pulp, xylose monomers, malic acid, xylonic acid, and phenolic BCD-oligomers was successfully transferred from lab scale to pilot scale (TRL 5)**

**Products samples were produced**

**The efficiency of the organosolv process (especially lignin recovery) was increased significantly**

**Different pathways to valorize the hemicellulose fraction were developed:  
A combination of adsorption, hydrothermal treatment, and nanofiltration processes, resulted in 90% of the oligomeric xylose in the hemicellulose hydrolysate being converted to monomeric xylose**

**Production costs and ghg-emissions were calculated for all products**



Nitzsche, Roy, Arne Gröngroft, Jakob Köchermann, Kathleen Meisel, Hendrik Etzold, Marlen Verges, Moritz Leschinsky, et al. 2020. 'Platform and Fine Chemicals from Woody Biomass: Demonstration and Assessment of a Novel Biorefinery'. *Biomass Conversion and Biorefinery*.

Köchermann, J., Schreiber, J., Klemm, M., 2019. Conversion of D-xylose and hemicellulose in water/ethanol mixtures. *ACS Sustainable Chem. Eng.*

Köchermann, J., Mühlenberg, J., Klemm, M., 2018. Kinetics of Hydrothermal Furfural Production from Organosolv Hemicellulose and D-Xylose. In: *Ind. Eng. Chem. Res.* 57 (43), S. 14417–14427.

Nitzsche, R., Gröngroft, A., Kraume, M., 2019. Separation of lignin from beech wood hydrolysate using polymeric resins and zeolites – determination and application of adsorption isotherms. *Separation and Purification Technology* 209, S. 491-502.

Pufky-Heinrich D, Rößiger B, Röver R, Unkelbach G. Process scale-up for the production of bioaromatic compounds from lignin, *Chem. Ing. Tech.*, 2016, 88, 1229-1230.

Björn Rößiger, Robert Röver, Gerd Unkelbach, Daniela Pufky-Heinrich; Production of BioPhenols for Industrial Application: Scale-up of the Base-Catalyzed Depolymerization of Lignin; *Green and Sustainable Chemistry (GSC)*, Vol. 7, No. 3, 193-202, DOI:10.4236/gsc.2017.73015

Rössiger B, Unkelbach G. Pufky-Heinrich D. Base-Catalyzed Depolymerization of Lignin: History, Challenges and Perspectives in Lignin - Trends and Applications, 2018, ISBN 978-953-51-5674-1.

Rößiger B, Röver R, Unkelbach G, Pufky-Heinrich D. Production of Bio-Phenols for Industrial Application: Scale-Up of the Base-Catalyzed Depolymerization of Lignin, *Green Sustainable Chem.*, 2017, 7, 193-202, DOI: 10.4236/gsc.2017.73015

Schulze, Peter; Leschinsky, Moritz; Seidel-Morgenstern, Andreas; Lorenz, Heike (2019): Continuous Separation of Lignin from Organosolv Pulping Liquors - Combined Lignin Particle Formation and Solvent Recovery. *Industrial & Engineering Chemistry Research* 2019 58 (9), 3797-3810, DOI: 10.1021/acs.iecr.8b04736



## The project team

Arne Gröngroft  
Roy Nitzsche  
Jakob Köchermann  
Kati Görsch  
Marco Klemm  
Hendrik Etzold  
Kathleen Meisel  
Franziska Müller-Langer

## In cooperation with



[www.cbp.fraunhofer.de](http://www.cbp.fraunhofer.de)

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# Exemplary projects



KomBiChem<sup>Pro</sup>

Wood based biorefinery



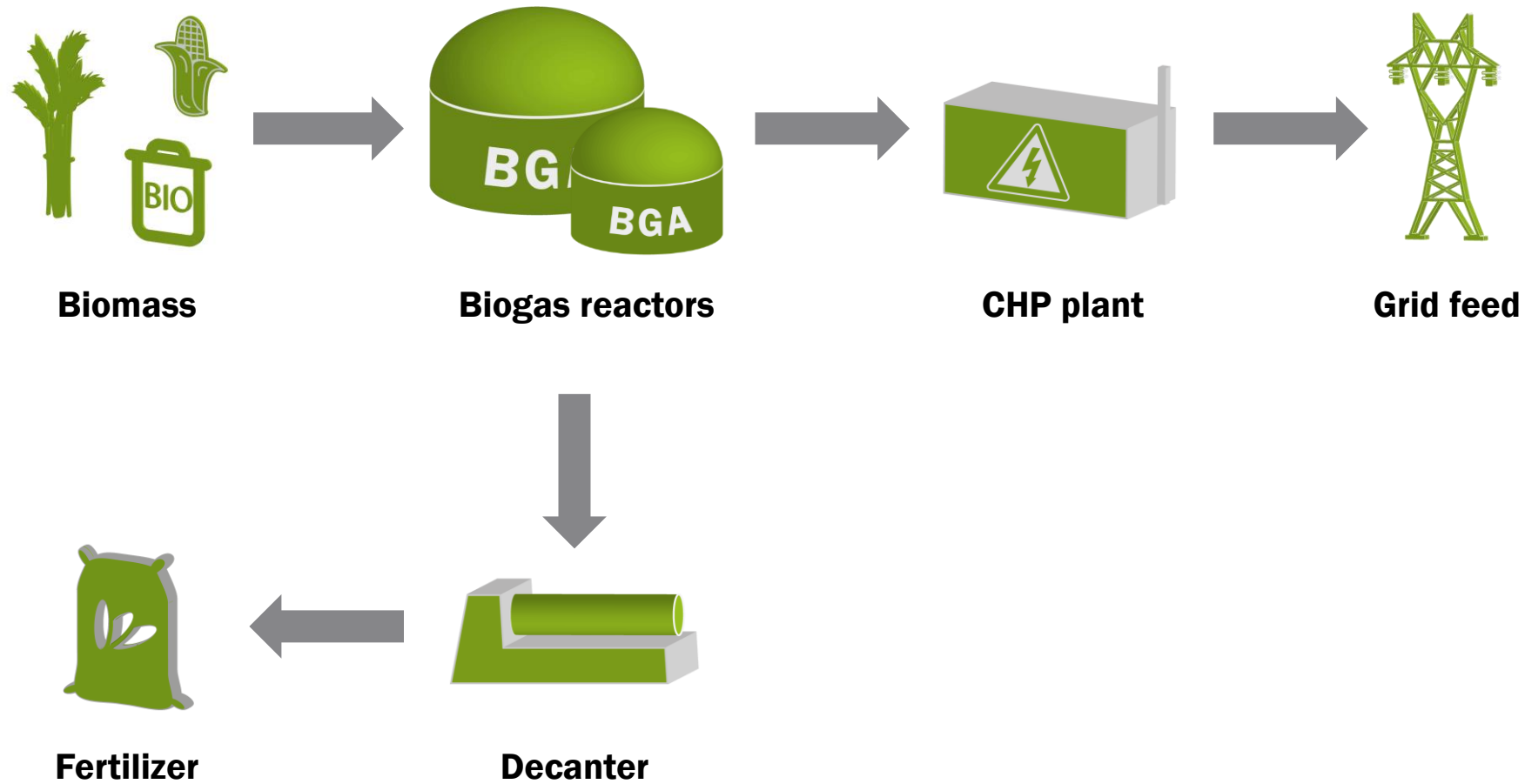
CapAcidy

**Biorefinery based on anaerobic  
fermentation of wet biomass**

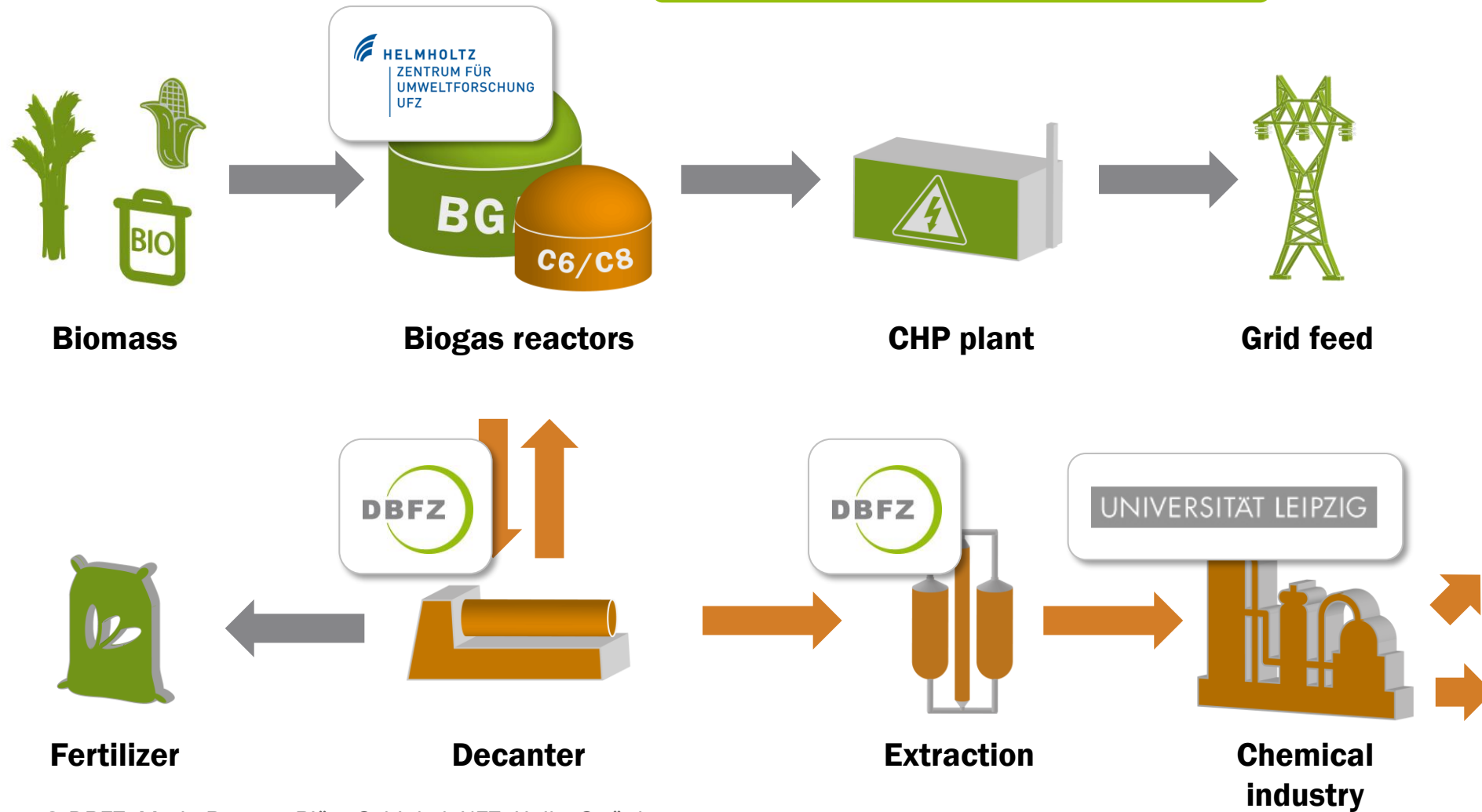
# CapAcidy

## Motivation and Aims

### Biogas plant of today ...



# Capacity Motivation and Aims



© DBFZ: Maria Braune, Björn Schinkel; UFZ: Heike Sträuber

# CapAcidy

## Methods in downstreaming

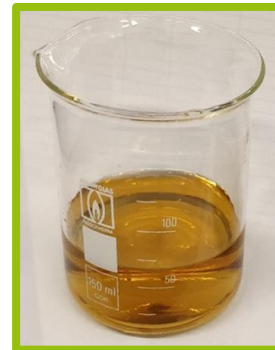


Fermentation  
broth



Solid  
phase

Liquid  
phase



Permeate



Extract



Caproic-/Caprylic acid



**Filter press/Decanter**



**Membrane filtration**



**Extraction**



**Distillation**

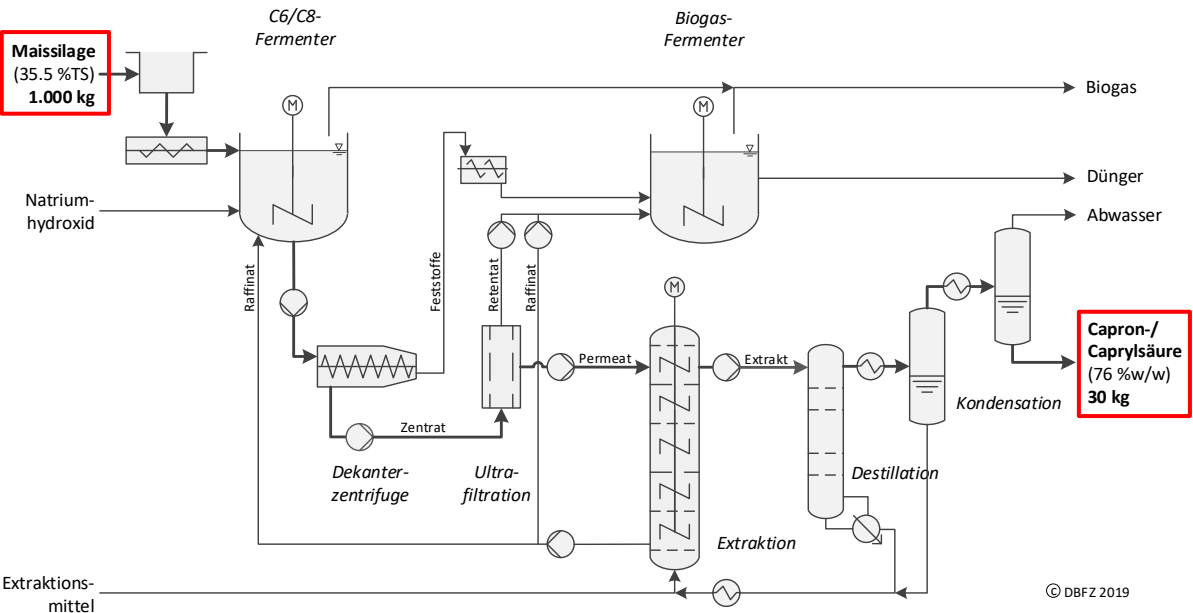




Concept for implementation

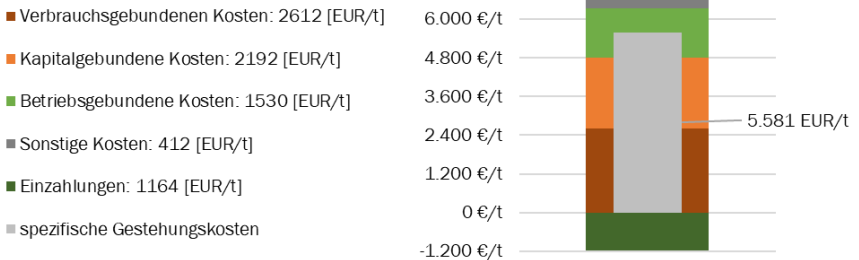


Final assessment



Production costs

Scenario 1



Scenario 2



# Main results and their exploitation

Process for a combined material-energetic use of biomass for the production of caproic and caprylic acid as well as biogas and fertilizer was developed

- Whole process chain from idea to small product volumes for the industrial partners was demonstrated
- Continuous process and zero-waste approach was developed
- Use of complex wet biomass is possible

### Fermentation:

12 % of the organic dry matter was converted into medium chain fatty acids (yield: C6-C8 =  $124 \pm 4$  g kg<sup>-1</sup> oTS)

Rest of the biomass is available for subsequent biogas production

### Downstreaming:

Complete removal of solids by filter press and ultrafiltration membrane (ceramic) without acid retention

Screening for a selective, biocompatible solvent and achievement of high extraction efficiencies (C6: 65 %, C8: 96 %)

### General benefits:

Integration into existing biogas plants and use of the plant infrastructure is possible





## CapAcidy

### The project team

Maria Braune  
Heike Sträuber (UFZ)  
Arne Gröngroft

### In cooperation with



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**Thanks for your attention!**

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