

# WE COMBINE BIOLOGY AND ENGINEERING

Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB

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DBFZ

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# Fraunhofer IGB

## Facts and figures



founded in **1953**, since **1962**  
within the Fraunhofer-Gesellschaft

**8300 m<sup>2</sup>** infrastructure area –  
for the operation of plants up to  
demonstration scale



**€ 24.8 million**  
operational budget (2018)



**326**  
employees



# Locations of Fraunhofer IGB



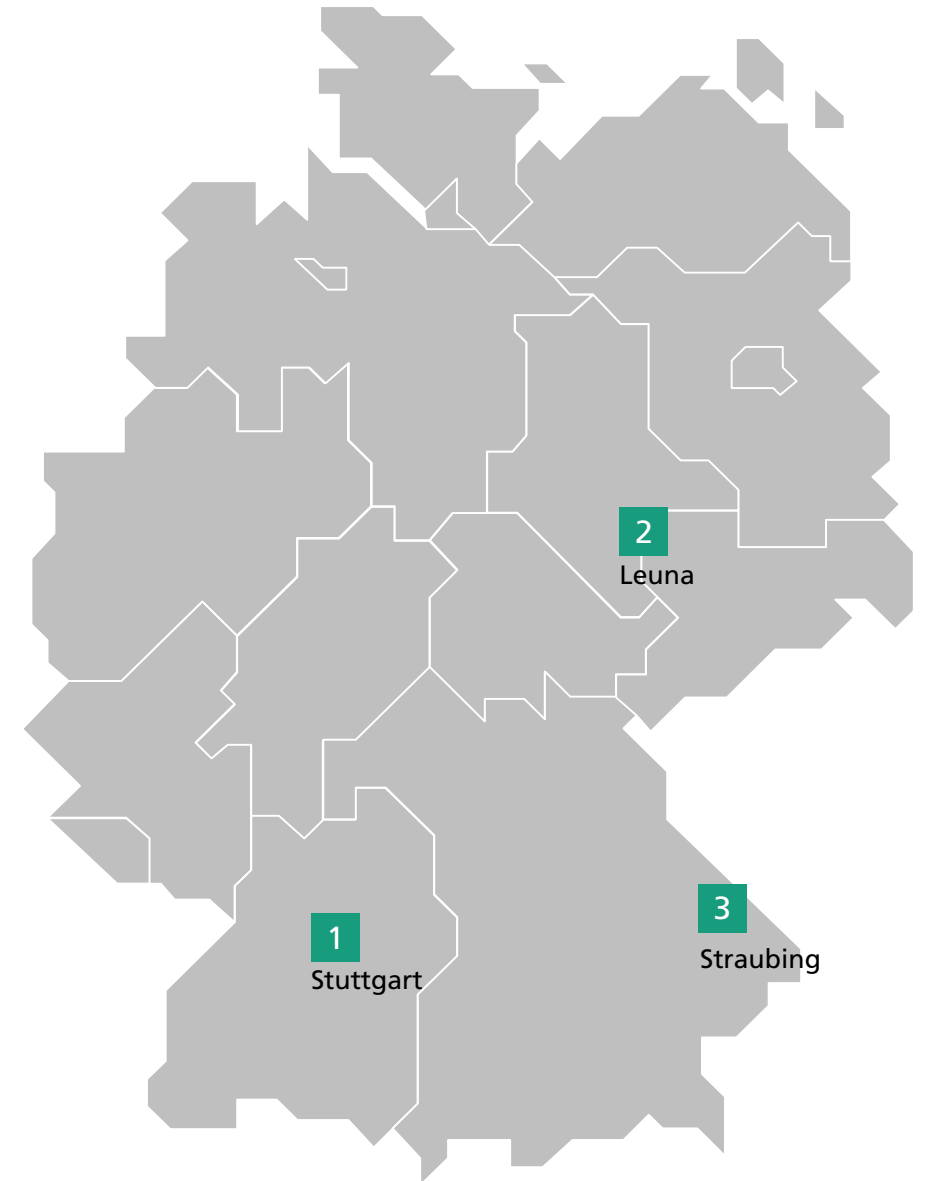
Fraunhofer Institute for Interfacial Engineering and Biotechnology **IGB**, Stuttgart



Fraunhofer Center for Chemical-Biotechnological Processes **CBP**, Leuna branch



Bio, Electro and Chemocatalysis **BioCat**, Straubing branch



# Business areas

## Innovative solutions for industry and society

### Health



- Molecular precision diagnostics
- Screening- and test systems for precision therapeutics
- Manufacturing processes for cell- and virus therapeutics
- Surfaces, materials and bio-inks for medical engineering

### Sustainable chemistry



- Biobased chemicals and materials
- Utilization of CO<sub>2</sub> and chemical recycling
- Tailor-made coatings
- Modular plant construction and demonstration / prototypes

### Environment



- Smart infrastructure – water, energy, food and waste
- New water treatment concepts
- Recovery and recycling of nutrients and metals
- Novel processes for reduction of greenhouse gases



# Equipment

## From laboratory to technical and pilot scale



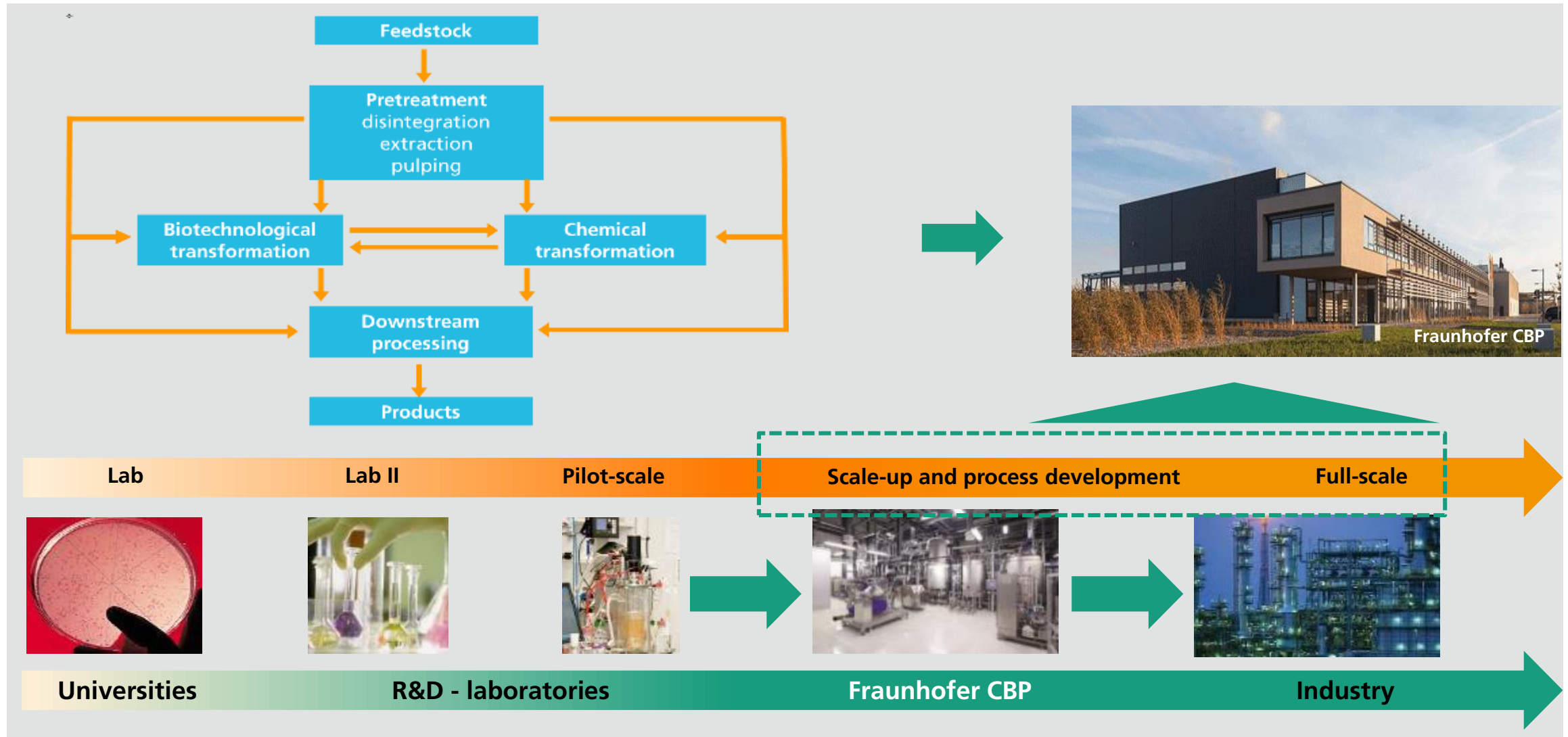
# FRAUNHOFER CENTER FOR CHEMICAL-BIOTECHNOLOGICAL PROCESSES CBP

The open scale-up facility of Fraunhofer IGB at the chemical site Leuna

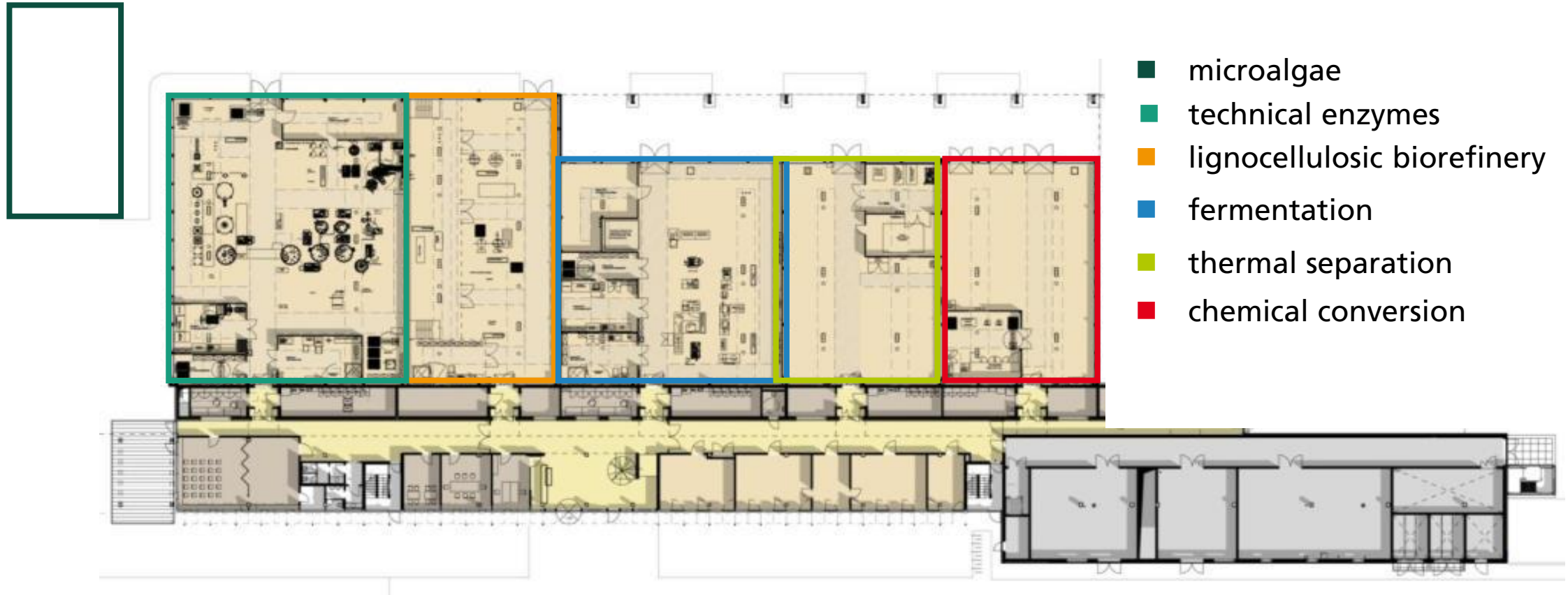




# Fraunhofer CBP: From laboratory to industrial scale



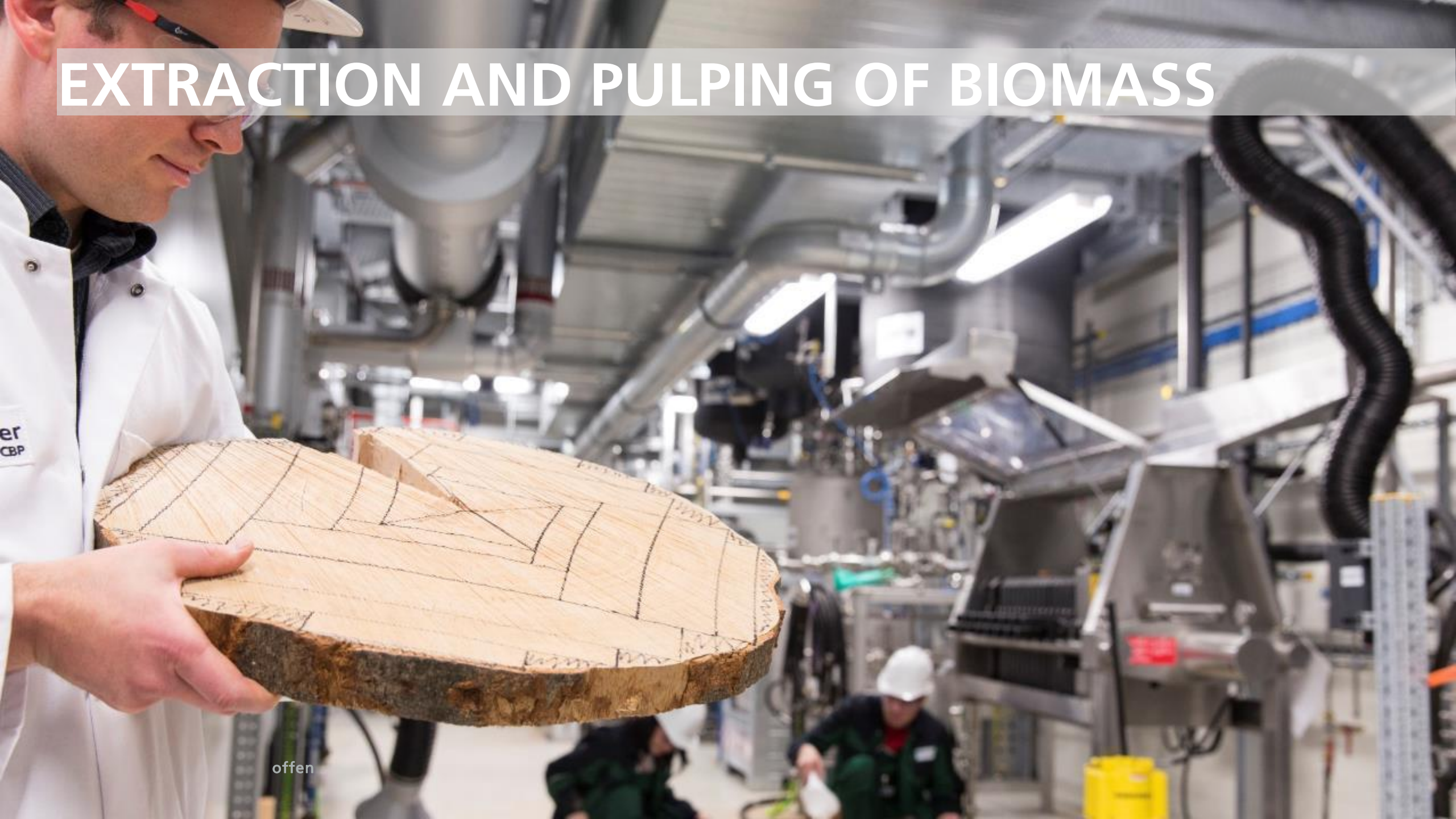
# Modular pilot plants for different biorefinery processes



- Bio safety level S1 approval, partwise ATEX-compatibility and floor coating according to WHG
- All media directly accessible: RO-water, steam, pressurized air, N<sub>2</sub>, O<sub>2</sub>, CO<sub>2</sub>, NH<sub>3</sub> and cooling water
- Waste water inactivation and neutralization, off-gas incineration



# EXTRACTION AND PULPING OF BIOMASS



# Fractionation of Lignocellulose



Lignocellulose

## Fractionation Products

Cellulose

Glucose

Hemicellulose

Xylose

Lignin

## Applications

Pulp,

Fermentation to platform chemicals: ethanol, butanol, lactic acid, itaconic acid, succinic acid

Xylitol, oligosaccharides, acidic acid, furfural, biogas

Phenols, Vanillin, bioplastics, adhesives, resins, carbon fibers





# Core competence: Fractionation of Lignocellulose

## Processes

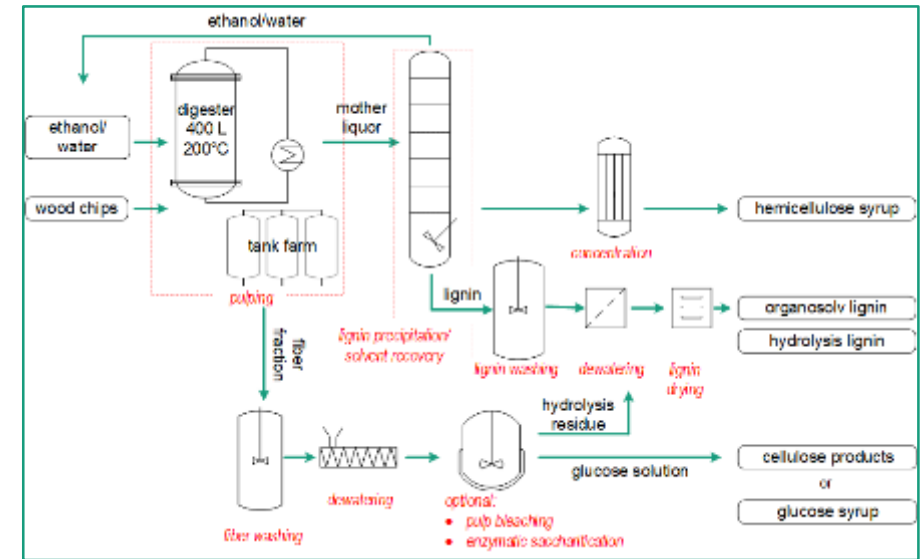
- Organosolv
- Alkaline/Soda pulping
- Extraction of valuable substances

## Raw materials

- Beech
- Spruce
- Eucalyptus
- Wheat straw
- Miscanthus
- Bark species

## We offer

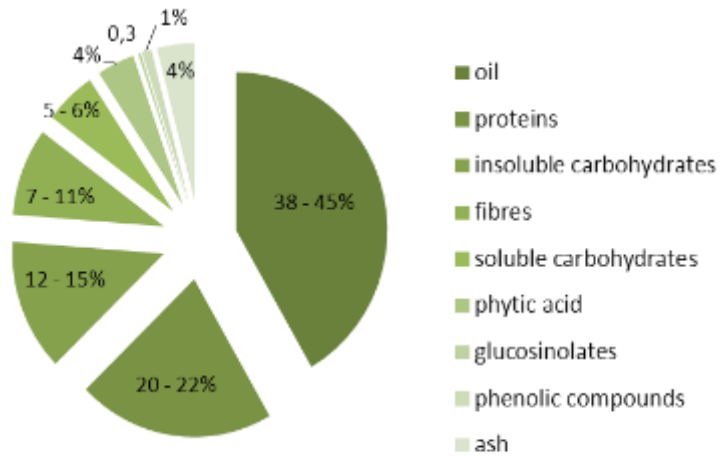
- Integrated process development and optimisation
- Process analytics
- Product and process expertise



# Ethanolic Native Extraction of Peeled Rapeseed



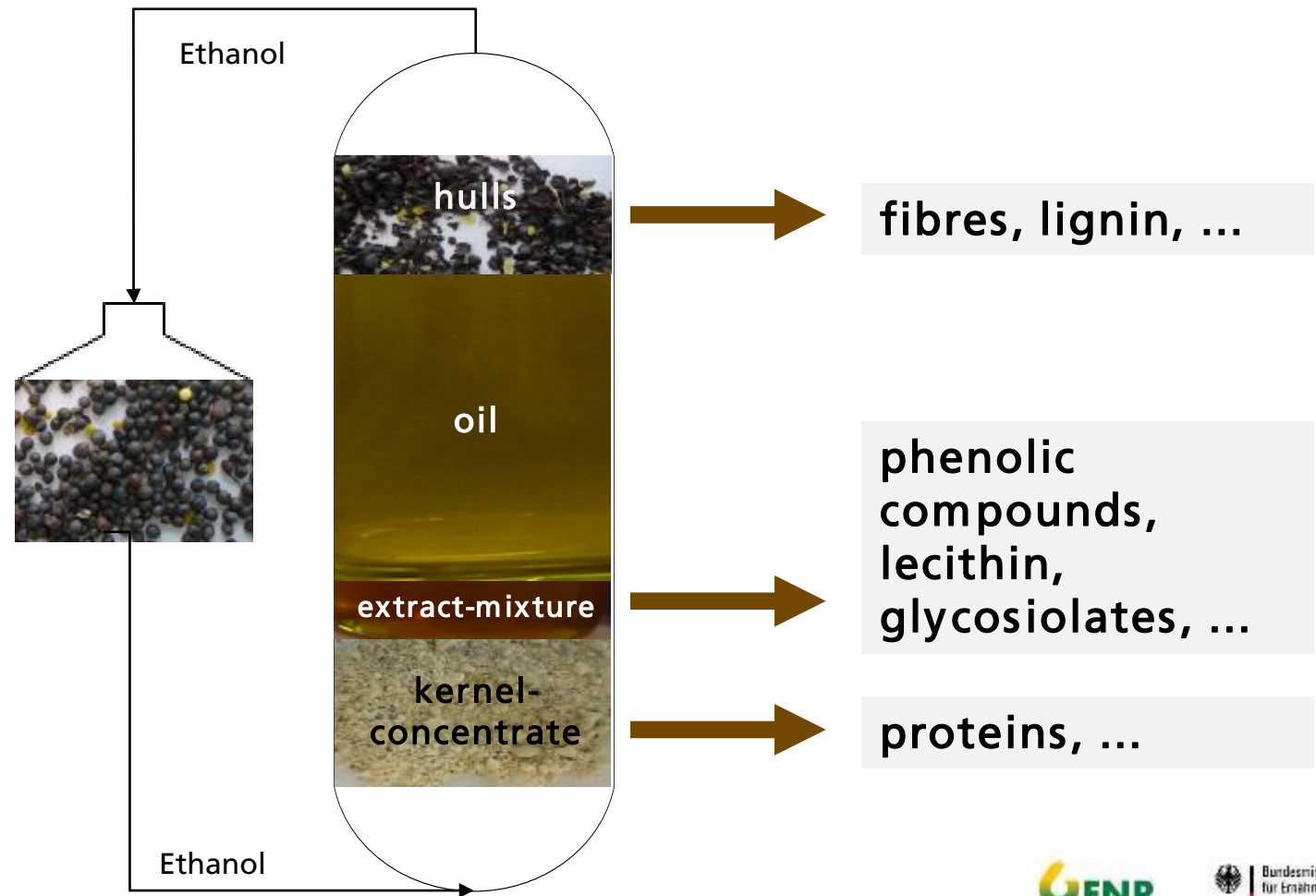
Composition of rapeseed



Source: Fraunhofer IVV



rapeseed → kernel → protein



65





# References

## processes



Ethanol-water  
organosolv process



Different  
fractionation  
processes



Mild FABIOLA™  
fractionation  
using acetone



Aquasolv process

## products



Carbon fibers

**Lignoplast**

Adhesives,  
coatings, polyur-  
ethane, epoxides

**Liberate**

Electrochemical  
depolymerisation  
of lignin



Xylose  
applications



Raw materials for  
hydrothermal  
carbonisation

**Xylosolv**

Pharmaceutic  
products from  
lignocellulose

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offen



# BIOTECHNOLOGICAL PROCESSES





# Equipment - Biotechnological processes

## Upstream processing

- 10 L – 10 m<sup>3</sup> bioreactors (CIP & SIP)
- Greenhouse and outdoor plants for cultivation of microalgae
- Microbiology laboratories

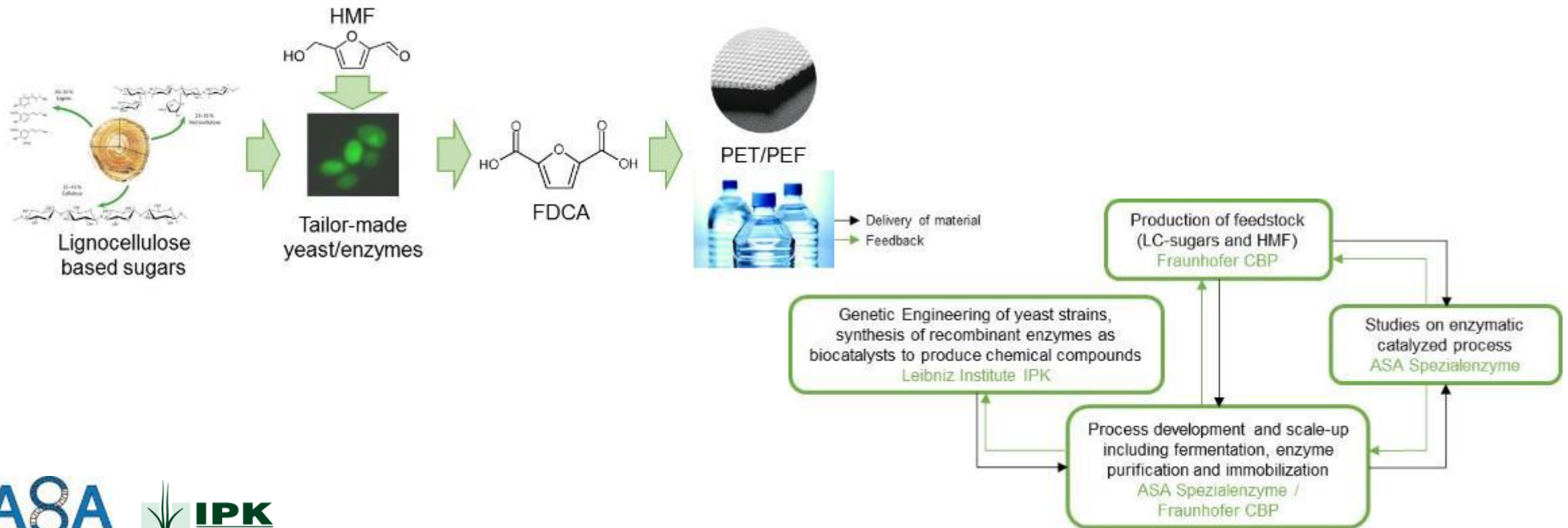
## Downstream processing

- Separator (cell separation)
- Homogenizer (cell disruption)
- Micro / ultrafiltration (concentration)
- Crystallization tank and vacuum filtration (conditioning)
- Chromatography (product fine cleaning)
- Freezing and spray dryer (product preservation)



# Lignocellulosic based enzymes for the conversion of 5-Hydroxymethylfurfural to 2,5-Furandicarboxylic acid »FDCAzymes«

- Development of yeast expression systems and fermentation processes based on lignocellulosic sugars to produce tailor-made enzymes for the catalysis of 2,5-Furandicarboxylic acid



# References

## Technical sugars



MetZyme® LIGNO  
*E. coli*  
10 m<sup>3</sup> + DSP



lipases  
*E. coli* + *P. pastoris*  
1 m<sup>3</sup> + DSP



feed  
*R. glutinis*  
1 m<sup>3</sup> + DSP



RESVERATROL  
*S. cerevisiae*  
10 m<sup>3</sup> + DSP



feed  
*E. coli*  
DSP



acetone  
*Clostridium* spp.  
100 L + DSP



imin reductases  
*E. coli*  
10 m<sup>3</sup> + DSP



biostimulants  
*Rhizobiaceae*  
10 m<sup>3</sup>

## Sugars from lignocellulose



itaconic acid  
*Aspergillus* spp.  
1 m<sup>3</sup> + DSP



alcohols  
*C. beijerinckii*  
100 L + DSP



malic acid  
*A. oryzae*  
1 m<sup>3</sup> + DSP

xylonic acid  
*G. oxydans*  
300 L



cellulases  
*P. verruculosum*  
1 m<sup>3</sup> + DSP



oxidases  
*A. adenivorans*  
300 L + DSP



# MICROALGAE CULTIVATION





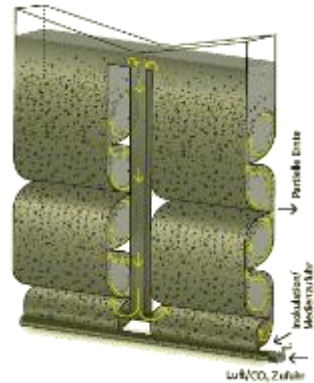
# Algae bioprocess engineering – cultivation

## Pilotplants

- FPA-reactors (Subitec)  
18 rows, 110 reactors each
- Outdoor plants: 45x 180 L
- Green house: 25x6L, 25x30L, 15x180L
- 11,7 m<sup>3</sup> capacity

## In-house research

- reactor-design
- Screening of strains
- Cultivation in lab and process optimization



## products

- fine chemicals (fatty acids, pigments)
- carbohydrates
- lipids
- proteins



# Algae bioprocess engineering – downstream processing

## Pilotplants

- Disk separators
- High pressure extraction with propane or supercritical CO<sub>2</sub>



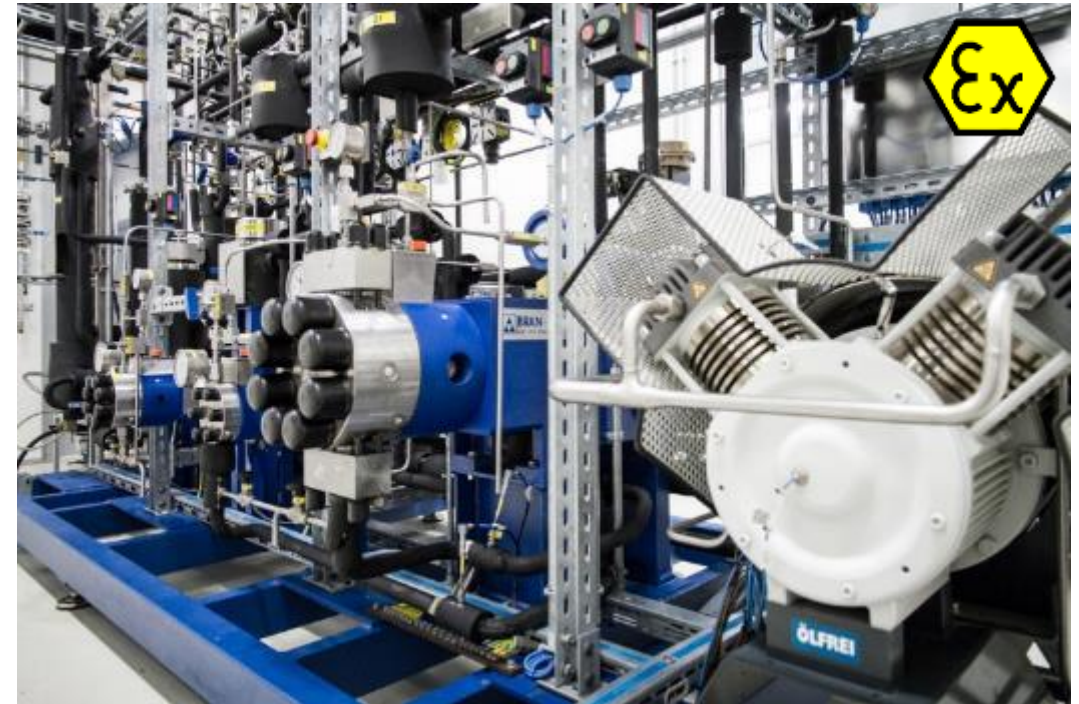
β-Glucane



Fucoxanthin



β-Carotene




# References

## Production of alga biomass





**Power2Feed**

Feed additives



**EMIBEX**

Biobased pigments



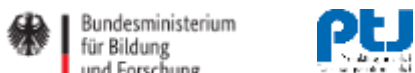
Fatty acids for polymer production

## Extraction and processing of alga biomass



**MAGNIFICENT**

Extraction of ingredients for cosmetic, food and feed industry



**EPI-CES**

Production and extraction with PCT technology



**OEKO-PROFUPA**

Biorefinery for fucoxanthin and EPA production



# SCALE-UP OF CHEMICAL PROCESSES





# Chemical processes - catalysis

## competences

- Reactions in gas and liquid phase
- Continuous or discontinuous catalytic reactions
- High pressure (up to 350 bar) and high temperature (up to 500 °C) reactions

## products

- Biofuels and additives for fuels
- Bio-based aromatic compounds



## Pilot plants

- Hydrothermal plant, including up- and downstream processing
- Stirred reactors for reactions under atmospheric pressure (100 L) and high pressure (50 L)
- Continuous high-pressure reactor



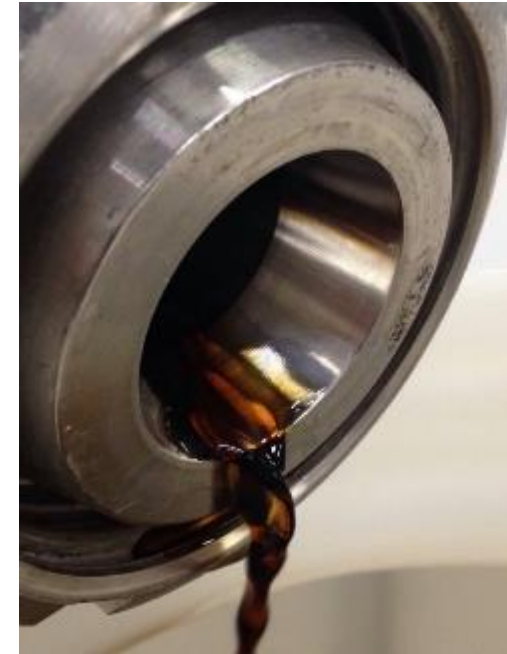
# Base-catalyzed depolymerization (BCD) of Lignin to Bio-Phenolics

Organosolv extraction

Isolation, purification, derivatisation



Base-catalyzed depolymerisation



# References

## Lignin



**ALIGN**  
Aromatics from LIGNIN

biobased  
aromatics for  
Phenolic resins



**FNR**  
**Lignoplast**

Adhesives, Paints,  
Polyurethane and  
epoxides



**BIO-BASED INDUSTRIES**  
Horizon 2020  
European Union Funding  
for Research & Innovation

Polyurethane,  
Phenoplastics,  
Epoxy resins



Chemie- und  
Biosystemtechnik  
**LiVe**

Product catalogue,  
Epoxy resins



WISSENSCHAFTSCAMPUS  
PFLANZENBASIERTE BIOÖKONOMIE  
HALLE  
**PhenoWood**


Optimization of  
BCD-Process



**FNR**  
**LignOx**

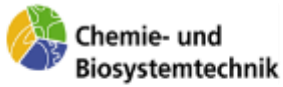
Biobased  
oligomers from  
lignin oxidation

## Epoxy resins



**EffiMat**

Biobased  
Epoxides



**BioMat**

Biobased  
Epoxide  
foams



**BEKs**

Flame retardant  
and biocidic  
Epoxy resins

## Surface active substances




**BeStKat**

Biobased kat.  
Surfactands




**FNR**  
**Integrierte  
BioProduktion**

Lubricants



**Bio - FAA**

Biobased  
Isooctene



**Bio - M**

Methanol

## Fuels and additives



# DOWNSTREAM PROCESSING AND PRODUCT ISOLATION



# Equipment Downstream processes

## Laboratory and pilot plants for mechanical and thermal separation processes

- Crystallizer, separators and equipment for filtration and membrane filtration
- 7 evaporators and distillation units for working at atmospheric pressure and under vacuum up to 350°C with a capacity of 1 L / h to 80 L / h
- Extraction plants for solid-liquid and liquid-liquid extraction under atmospheric conditions and under high pressure with liquid propane or supercritical carbon dioxide

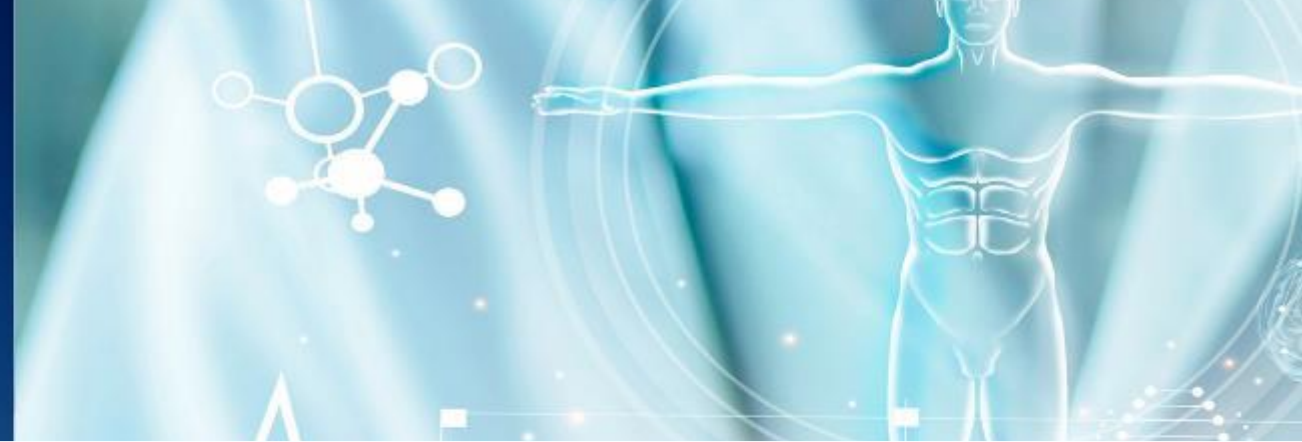




# Fraunhofer CBP accelerates the integration of new processes

- Owned and operated by Fraunhofer, therefore open to all interested parties
- State-of-the art technology and equipment in lab- to pilot-scale dimensions: feedstock pretreatment, conversion, downstream processing
- Reduction of scale-up time and costs for participants
- Operation of pilot plants owned by partners/clients also possible
- Training and further education programs, also in combination with initial training, retraining or university studies
- From one-day to multi-year-projects
- Flexible IP regulations
- Excellent national and international networks
- Several development projects implemented industrially at partners sites
- Expansion areas available in the immediate vicinity





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