TECHNISCHE UNIVERSITÄT DRESDEN

DRESDEN concept

Institute for Natural Materials Technology
Chair of Bioprocess Engineering

Direct Microbial Production of the Green Solvent Ethyl Acetate

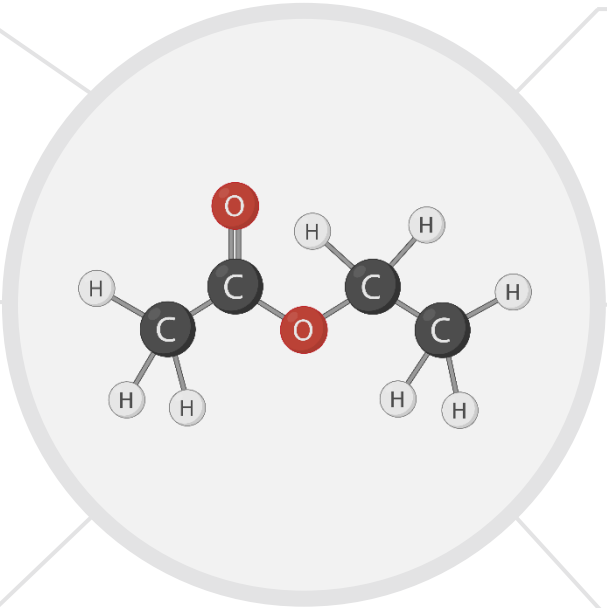
Prof. Thomas Walther

What is Ethyl Acetate?

Fruity smell

Volatile

Aroma compound
fruits and fermented beverages



Extracting agent
Decaffeinating coffee

Solvent
Nail polish remover, glues

Environm. friendly
biodegradable

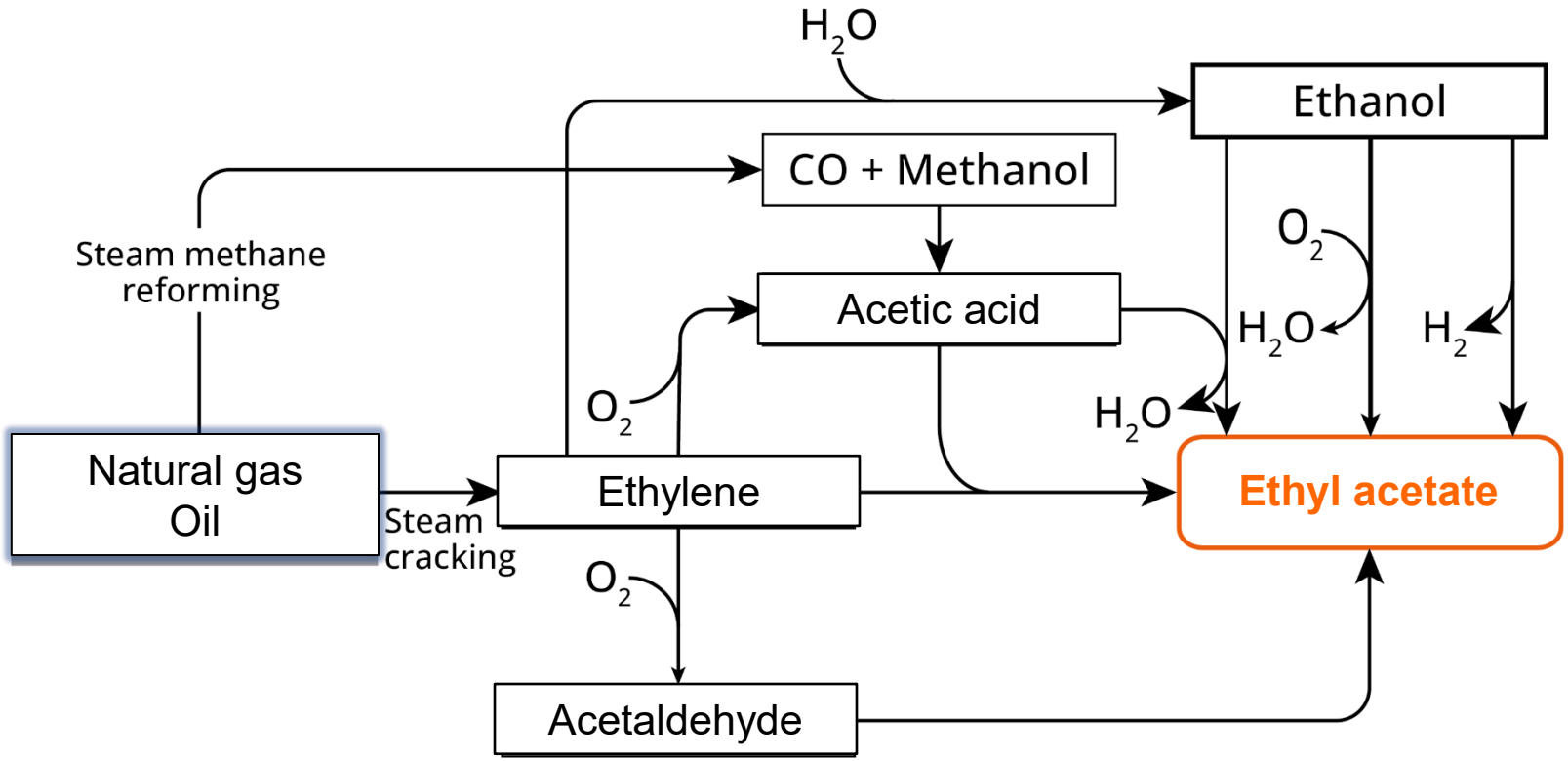
4.5 million tons are produced worldwide every year
Selling price is 1.28 $/kg (depends on global region)

What is Ethyl Acetate an Attractive Product?

- Considerable market volume (4.5 Mt/a)

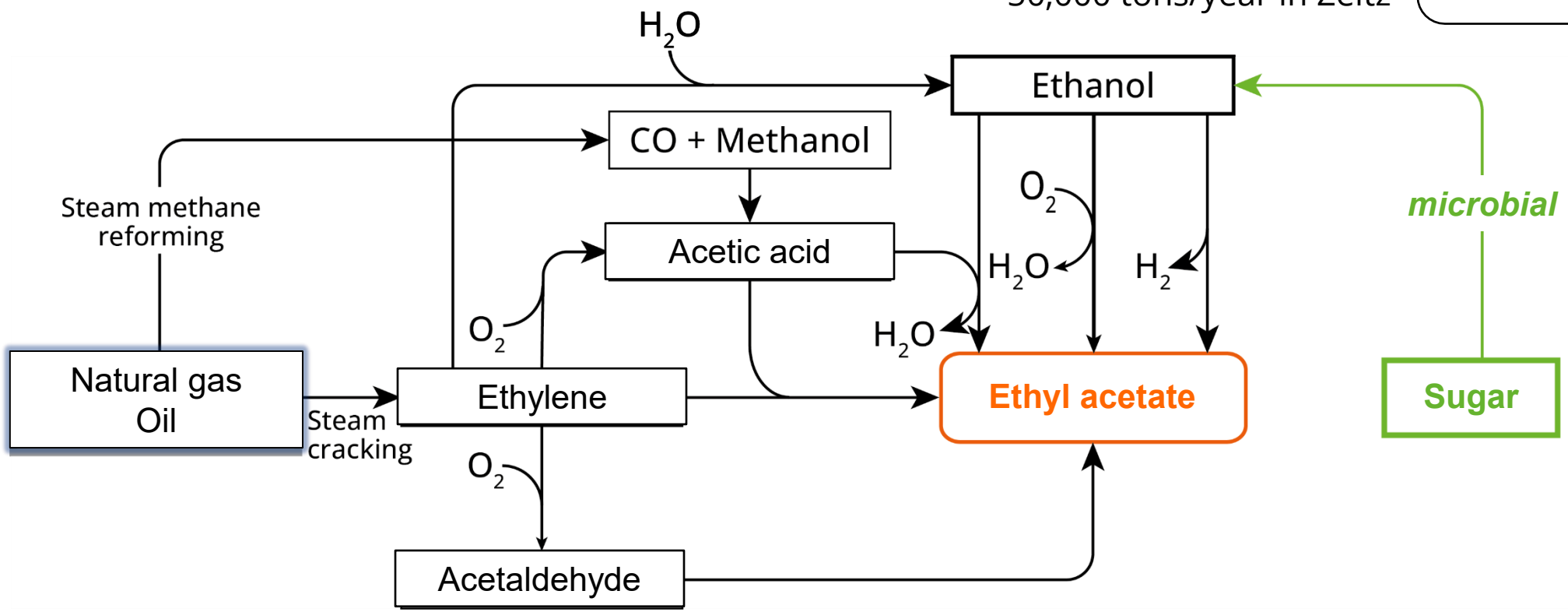
- Selling price of 1.3 $/kg is ~50-70 % higher than for ethanol. **-> Higher margin than for ethanol reference process.**

Current production of ethyl acetate



Current production of ethyl acetate

CropEnergies plans
Bio-ethyl acetate plant with
50,000 tons/year in Zeitz



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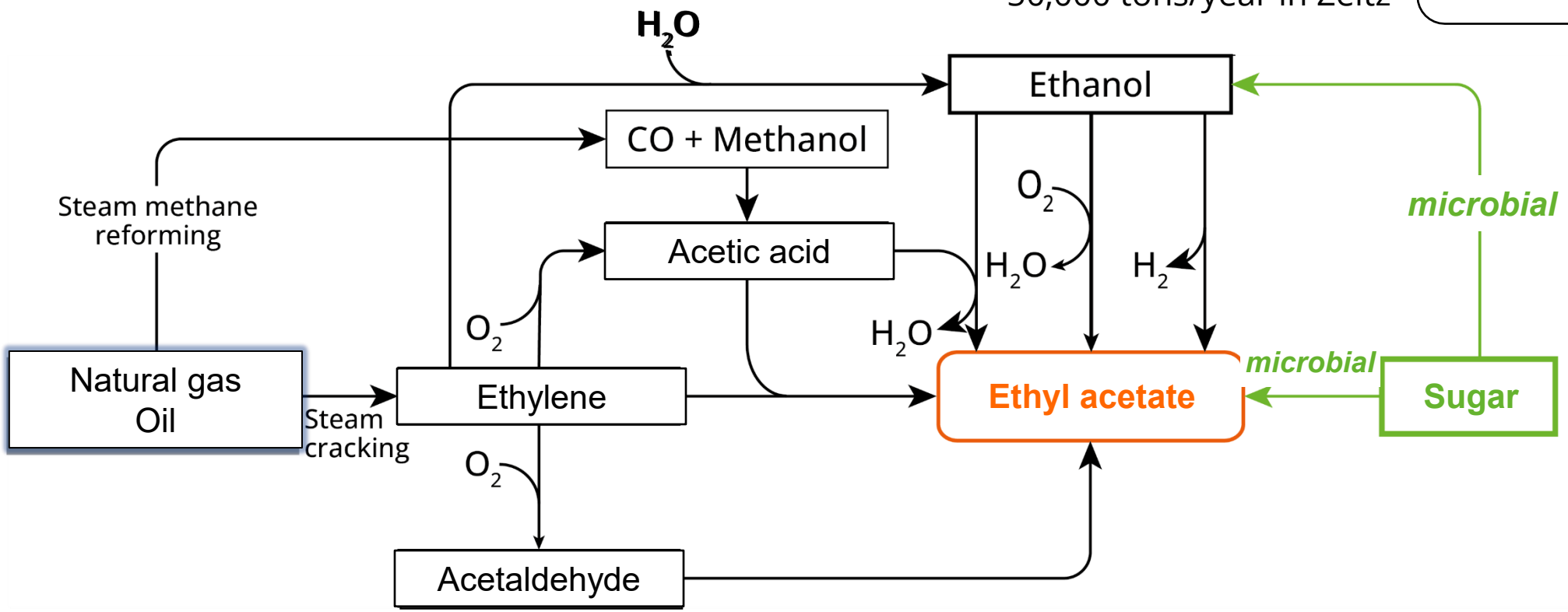
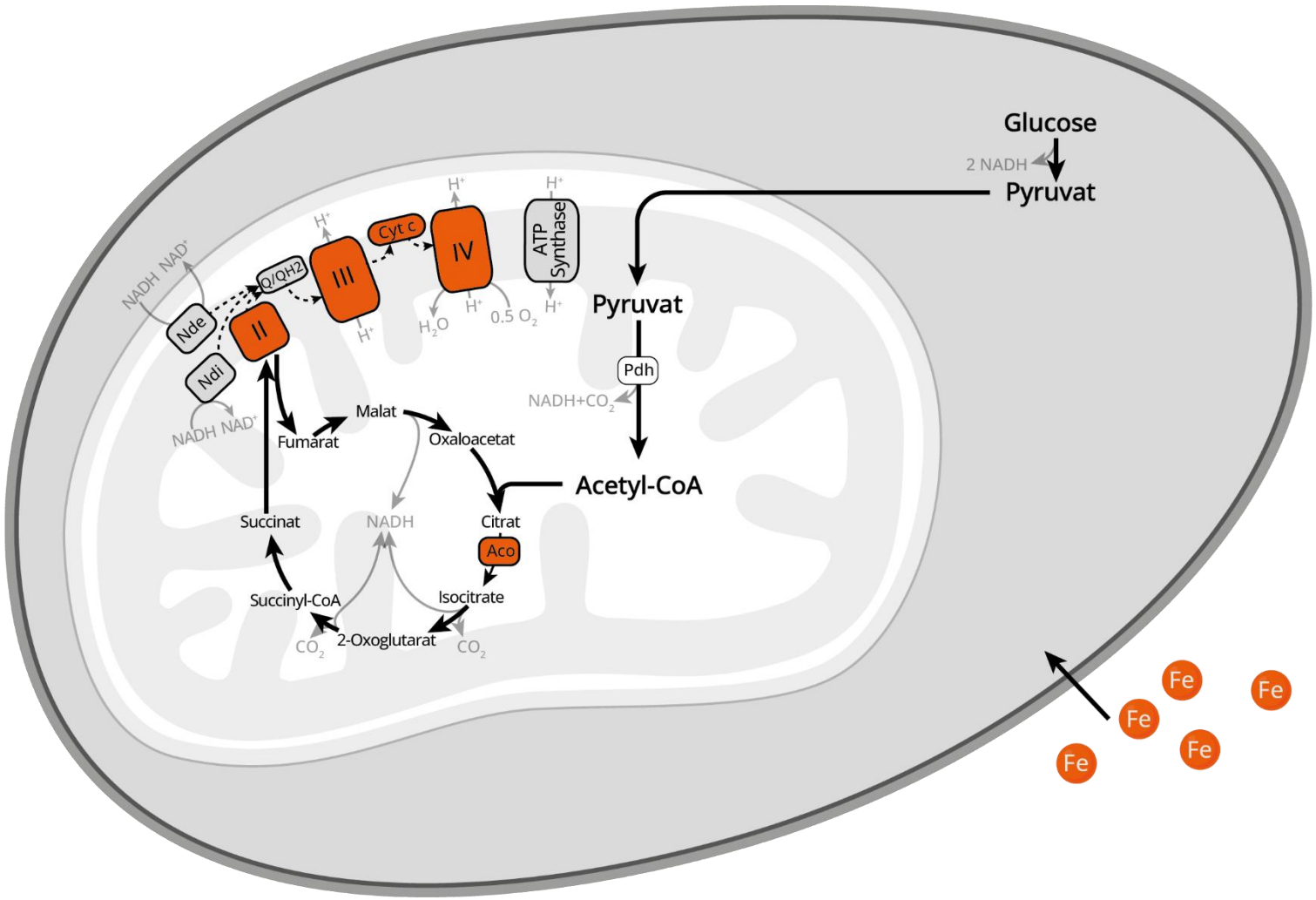
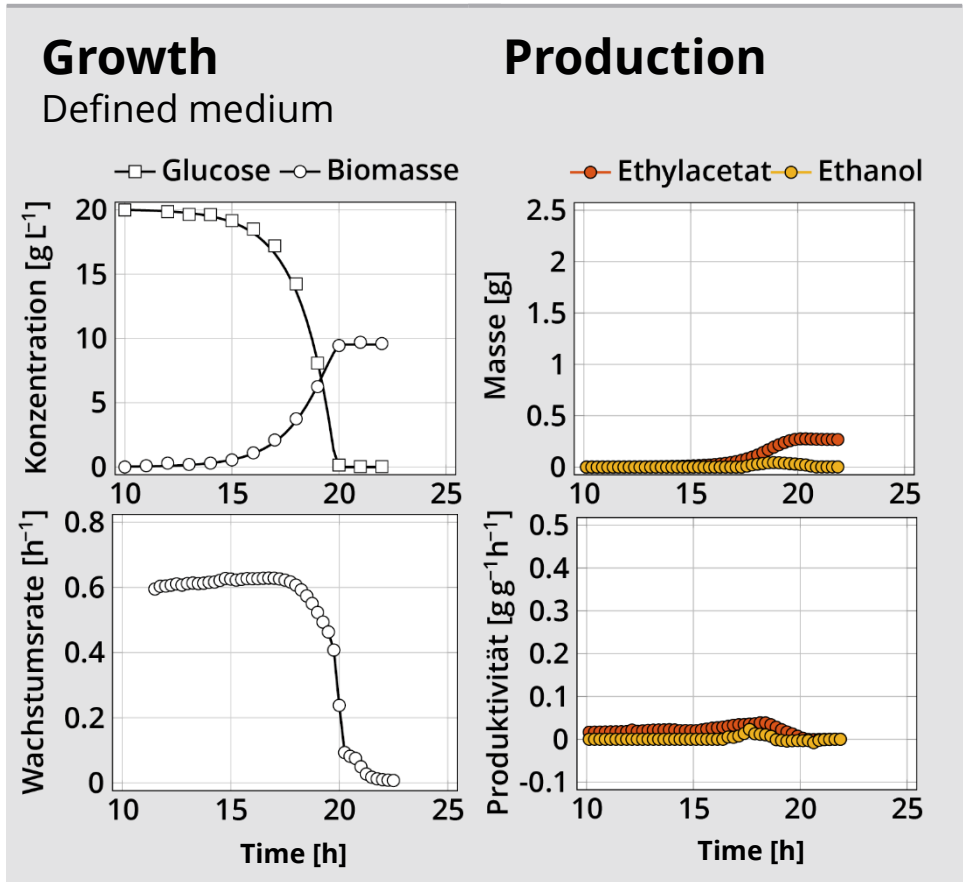


Microbial synthesis of ethyl acetate

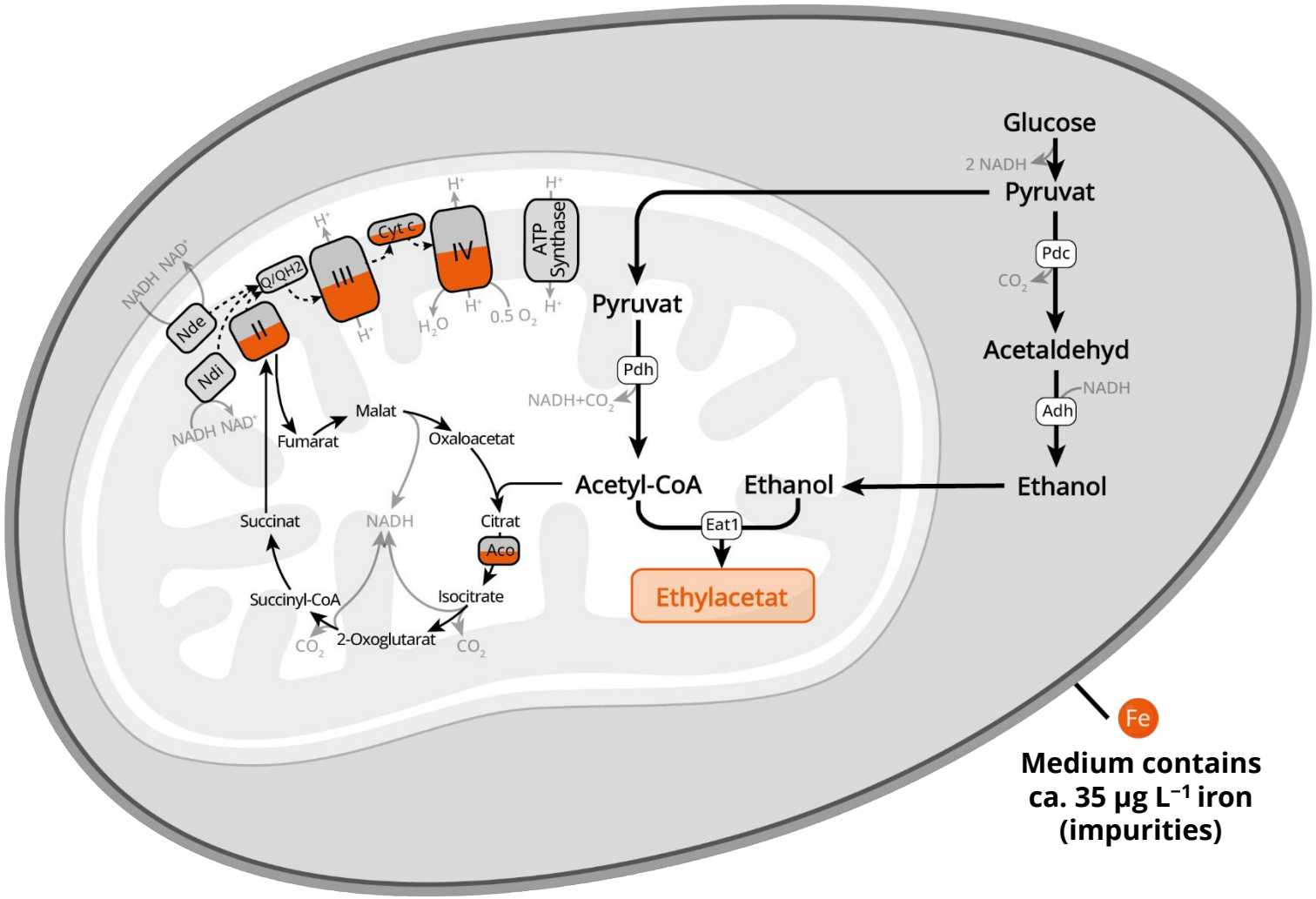
Unlimited growth of *Kluyveromyces marxianus* DSM 5422

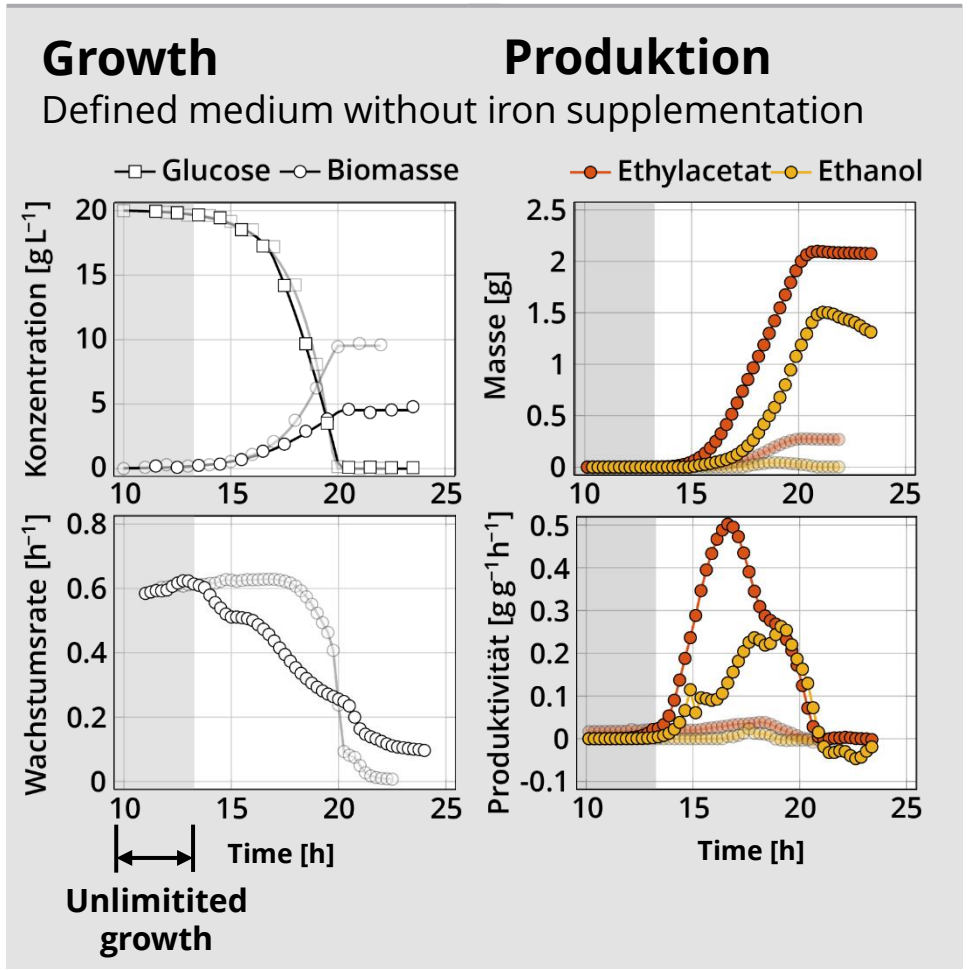




Microbial synthesis of ethyl acetate

Iron-limited growth of *K. marxianus* DSM 5422





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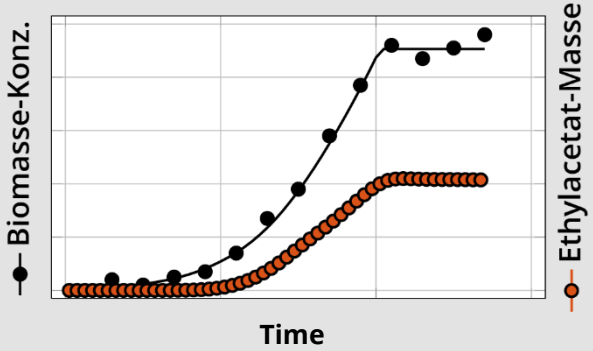
- EthAc can be produced by wild-type yeast. **-> Biomass can be sold as by-product (animal feed)**
-> Less constraints on waste treatment.

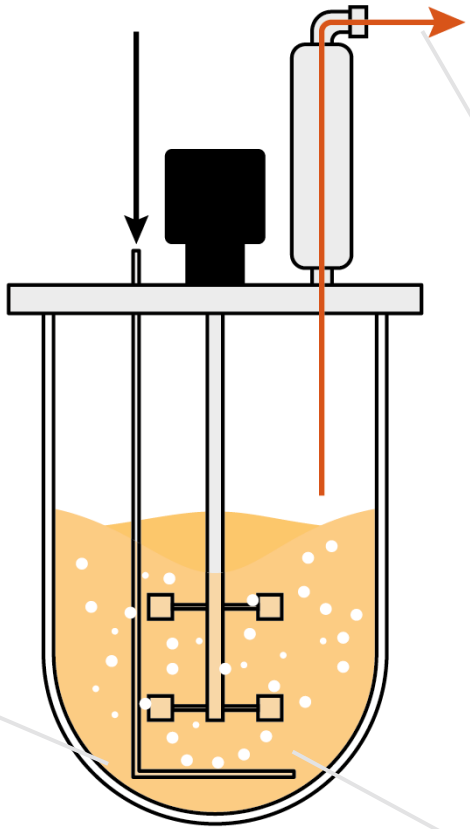
Ethyl acetate synthesis

Aerobic fermentation with *Kluyveromyces marxianus*

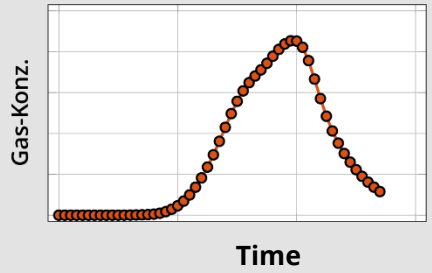
Aerobic cultivation



- Induction by iron limitation
- Growth

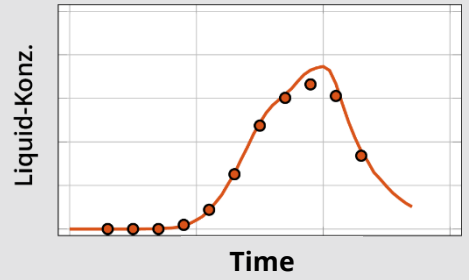


in situ product separation



- Stripped ethyl acetate can be condensed from the gas phase

Stripping of ethyl acetate



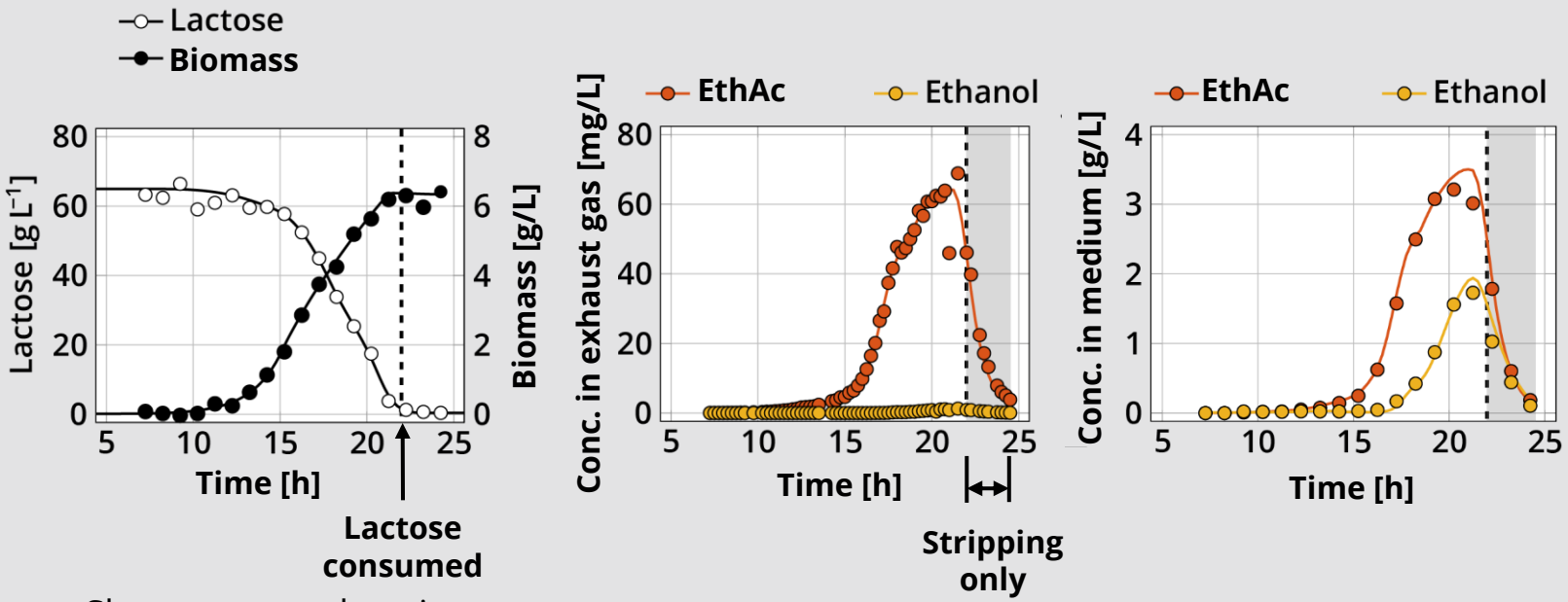
- Stripping of ethyl acetate
- Low liquid concentration
- Only low product inhibition

Ethyl acetate synthesis in an optimized molasses medium

Batch process with iron limitation

Growth and product development

in molasses medium at pH 5.1; gassing 1 vvm



- Short process duration
- Rapid separation of the ethyl acetate formed via stripping
- No product inhibition

What is Ethyl Acetate an Attractive Product?

- Considerable market volume (4.5 Mt/a)

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-> Higher margin than for ethanol reference process.

- EthAc can be produced by wild-type yeast.

-> Biomass can be sold as by-product (animal feed)
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- Product does not accumulate in the reactor.

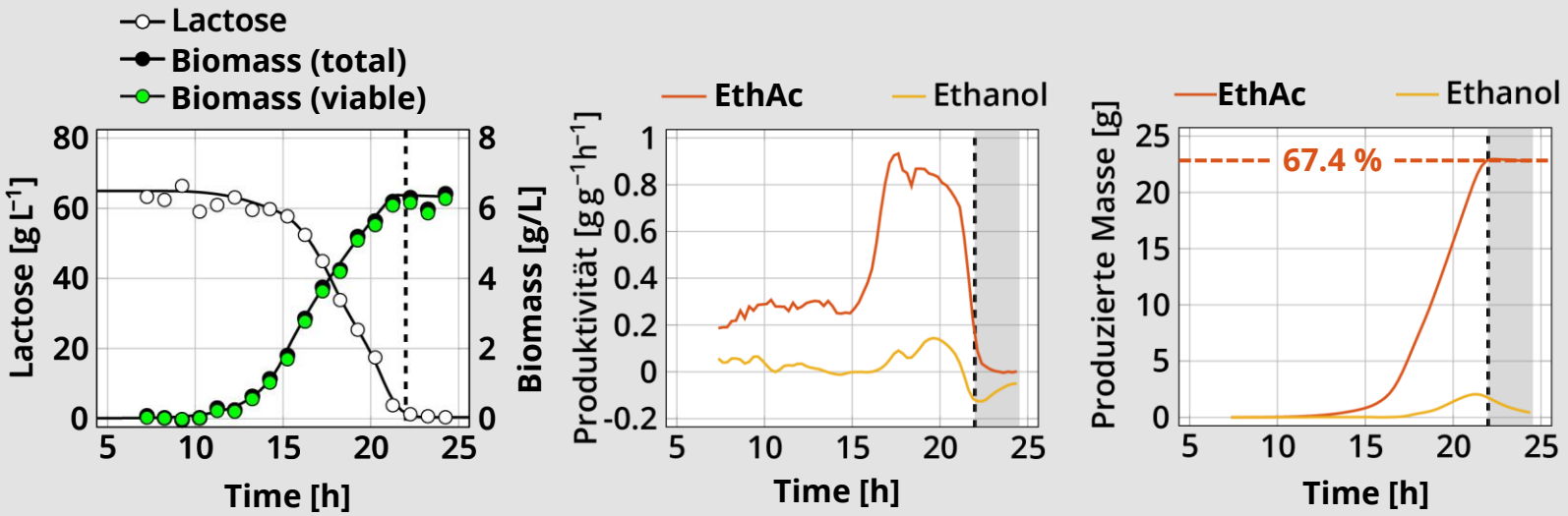
-> Decoupling of final product concentration from initial sugar concentration.
-> 2G feedstocks containing dilute sugars can be valorised.

Ethyl acetate synthesis in an optimized molasses medium

Batch process with iron limitation

Growth and product formation under optimal conditions

in molasses medium at pH 5.1; gassing 1 vvm

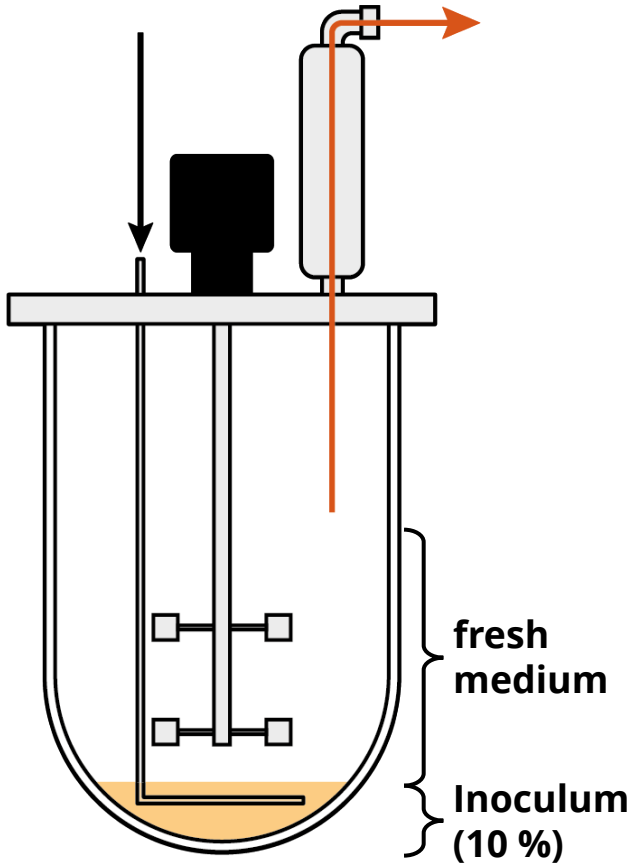


- Very high biomass-specific productivity
- 67.4 % of the maximum yield (Y_{max} = 0.49 g/g)
- Very high viability

→ Process is suitable for repeated batch operation

Ethyl acetate synthesis in an optimized molasses medium

Repeated batch process with iron limitation



Growth and product development

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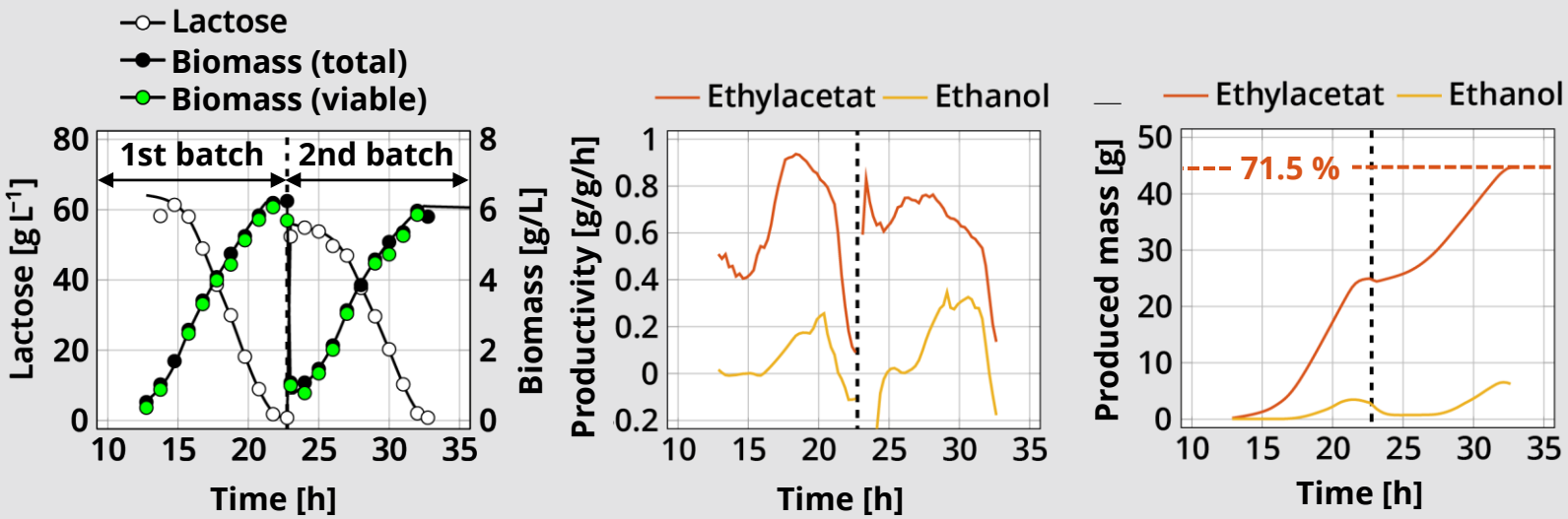

- Continued very high viability
- No interruption of the ethyl acetate synthesis
- Highest ethyl acetate yield to date achieved with wild-type yeasts

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- Carbon efficiency is reasonable (0.35 g/g).

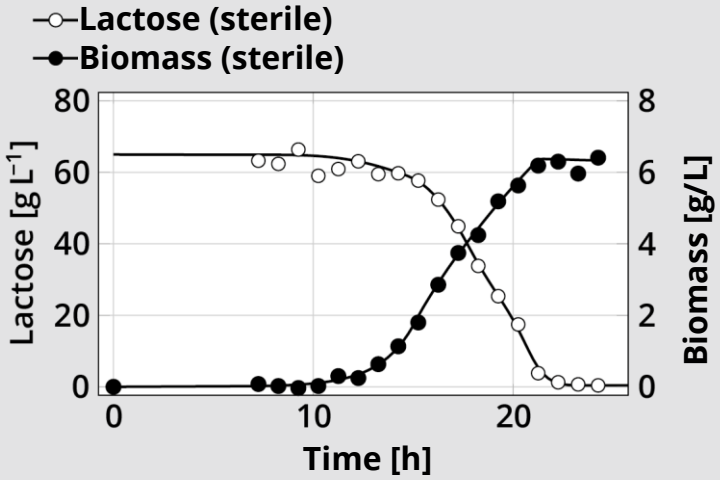
- Repeated batch fermentations are possible.

Ethyl acetate synthesis in an optimized molasses medium

Non-sterile batch process with iron limitation

Growth and product development

in non-sterile molasses medium at pH 5.1; gassing 1 vvm



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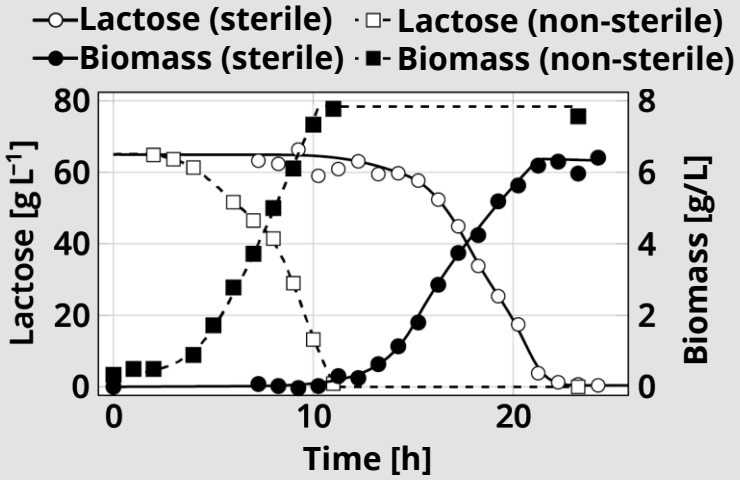

- No contamination detectable at the end of the process
- Fermentation possible under non-sterile conditions

Ethyl acetate synthesis in an optimized molasses medium

Non-sterile batch process with iron limitation

Growth and product development

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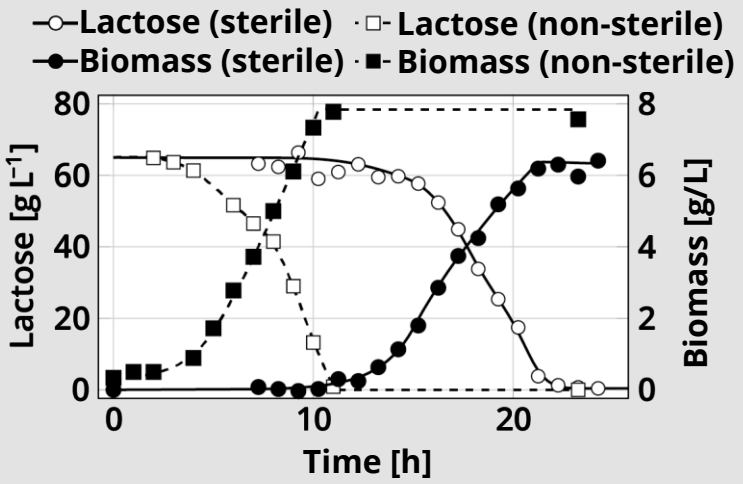

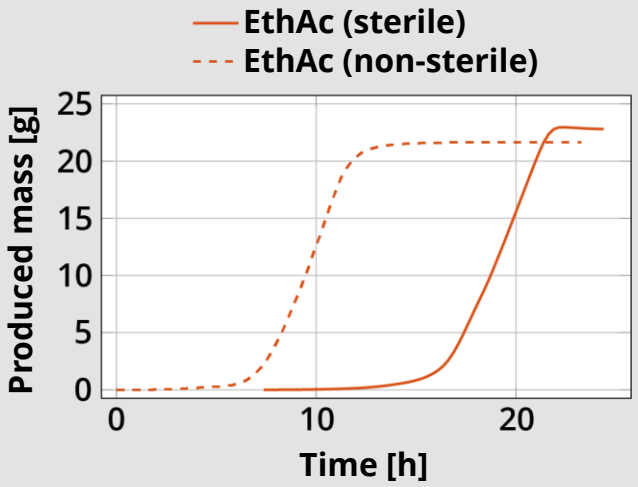

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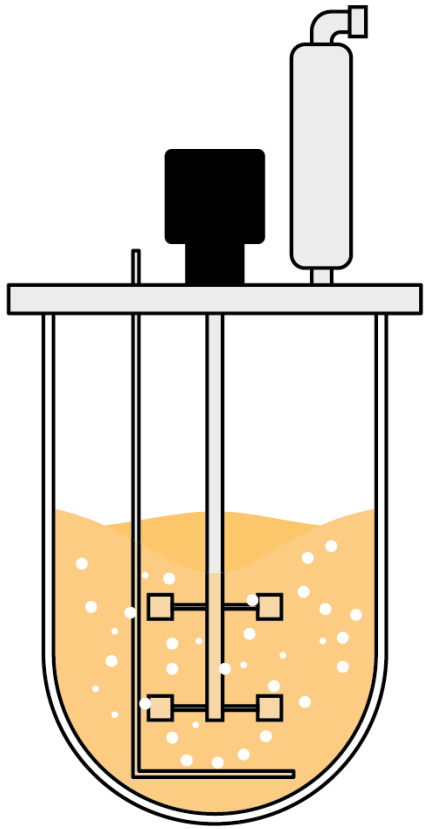
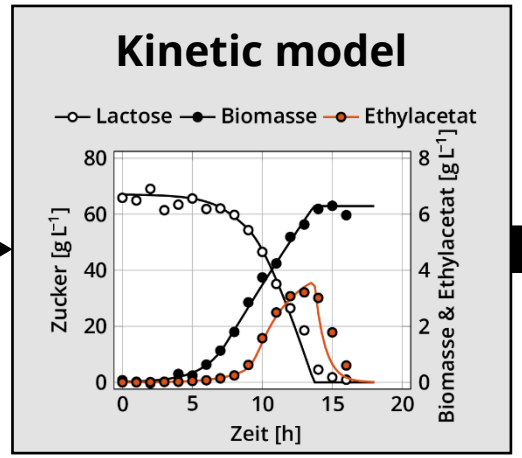
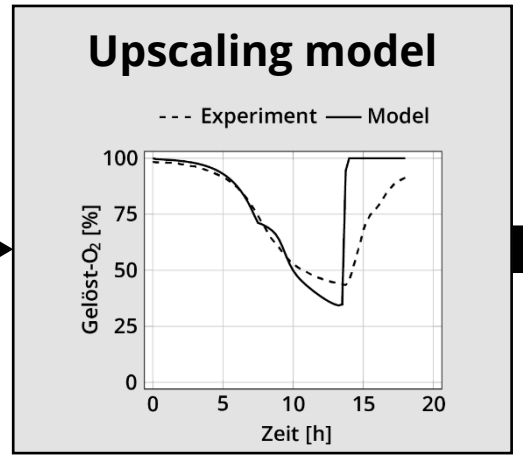
Computational upscaling and preliminary TEA

Repeated batch process with non-sterile molasses medium

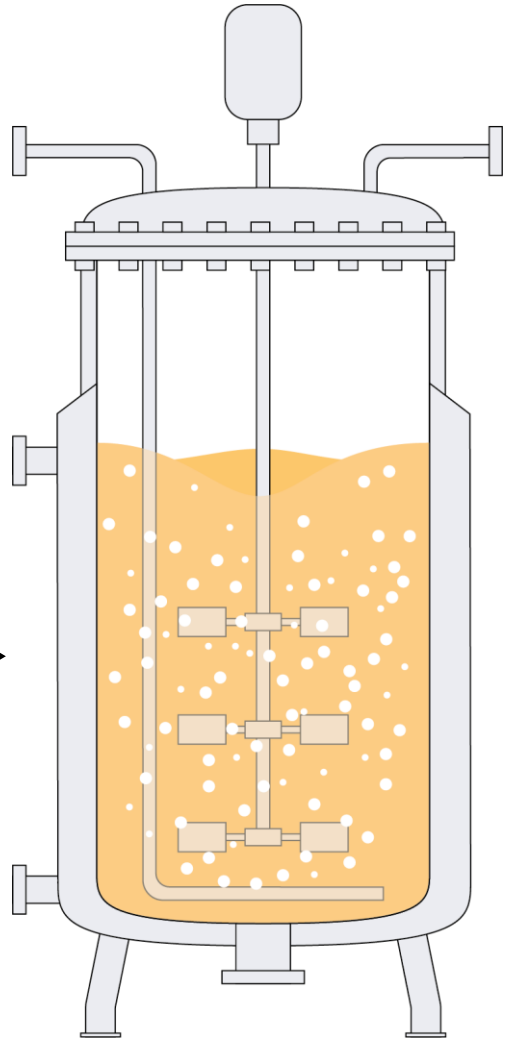


Laboratory scale (1 L)



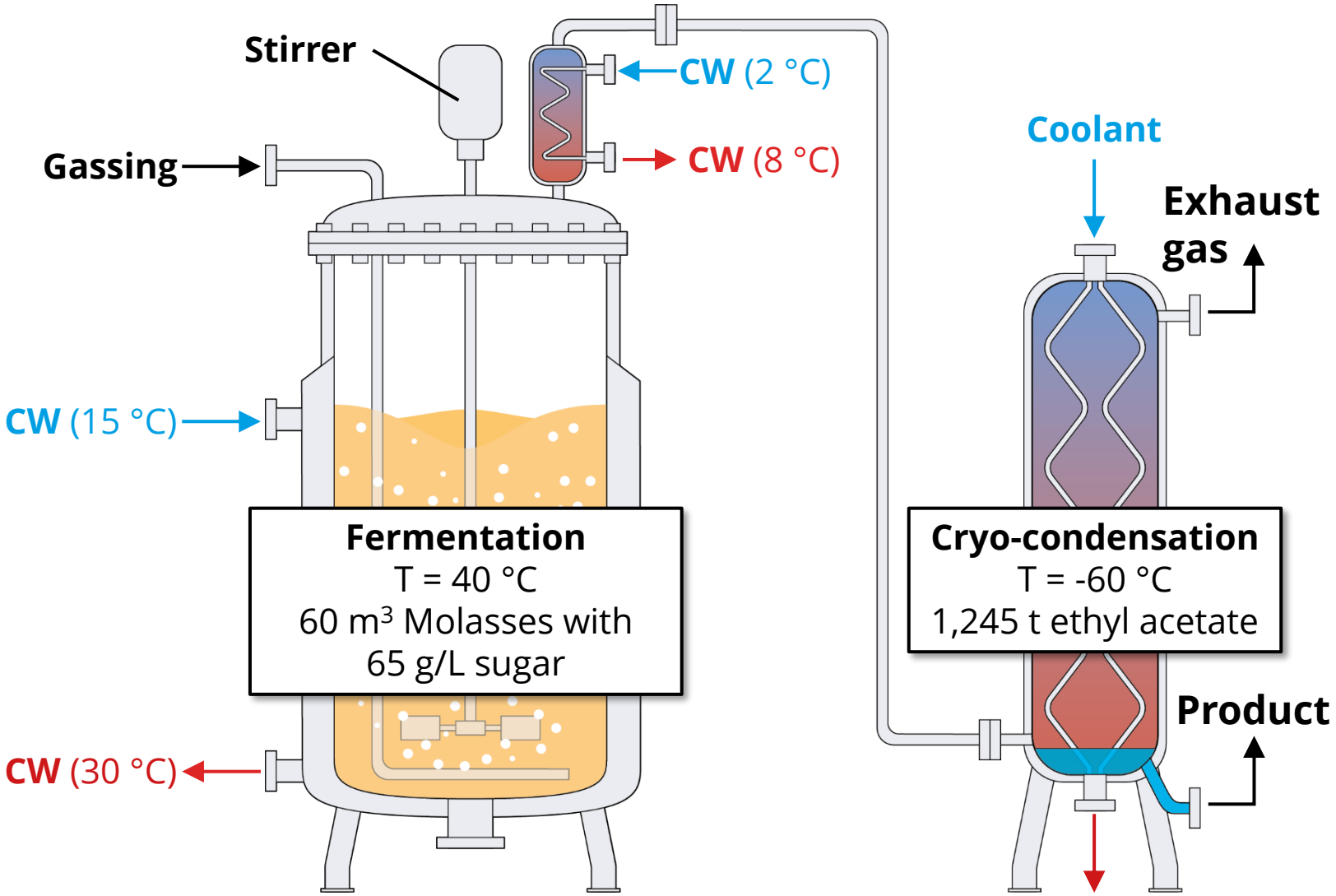


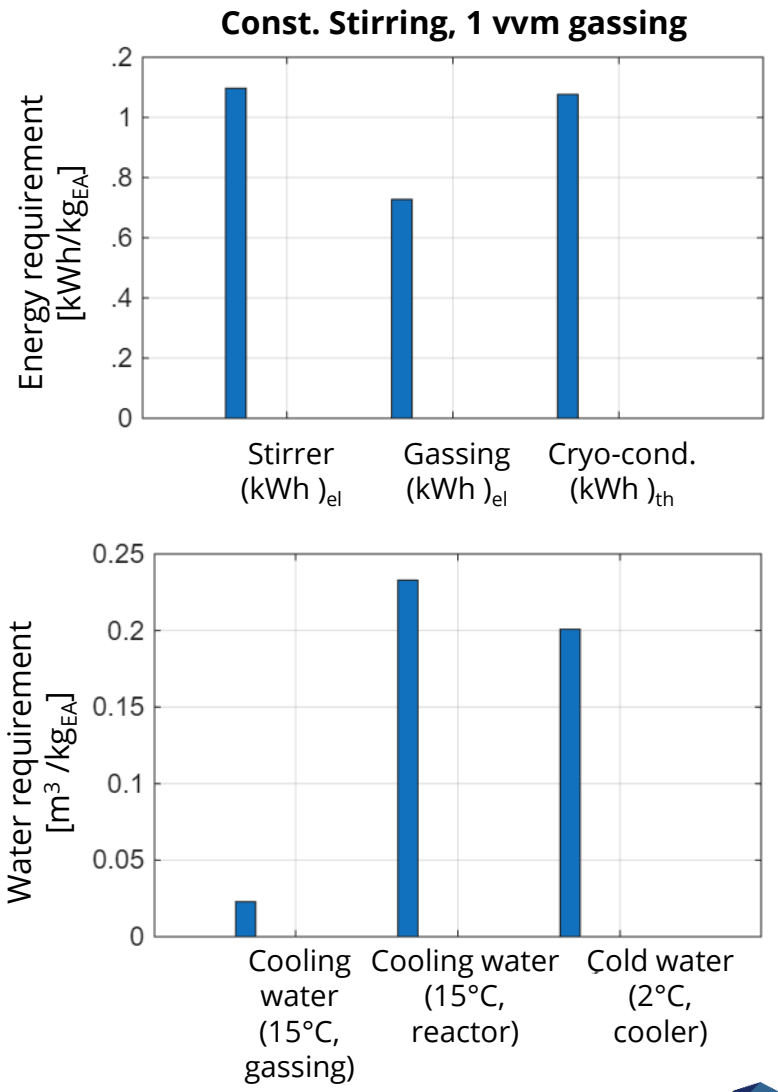
Dynamic process model was implemented in gPROMS



Industrial scale (60 m³)

Process optimization of ethyl acetate production

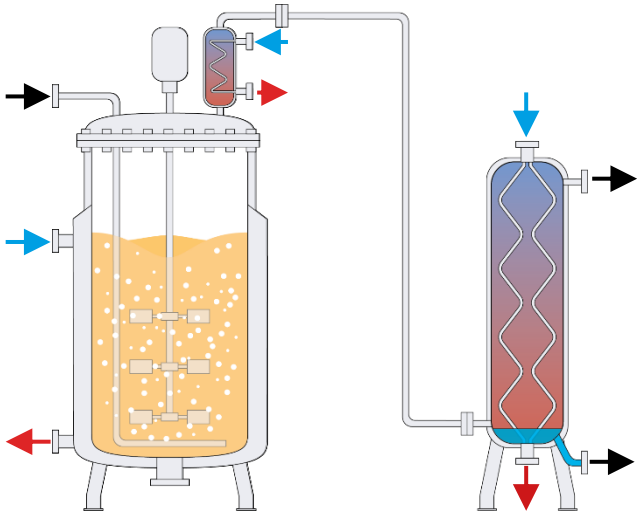


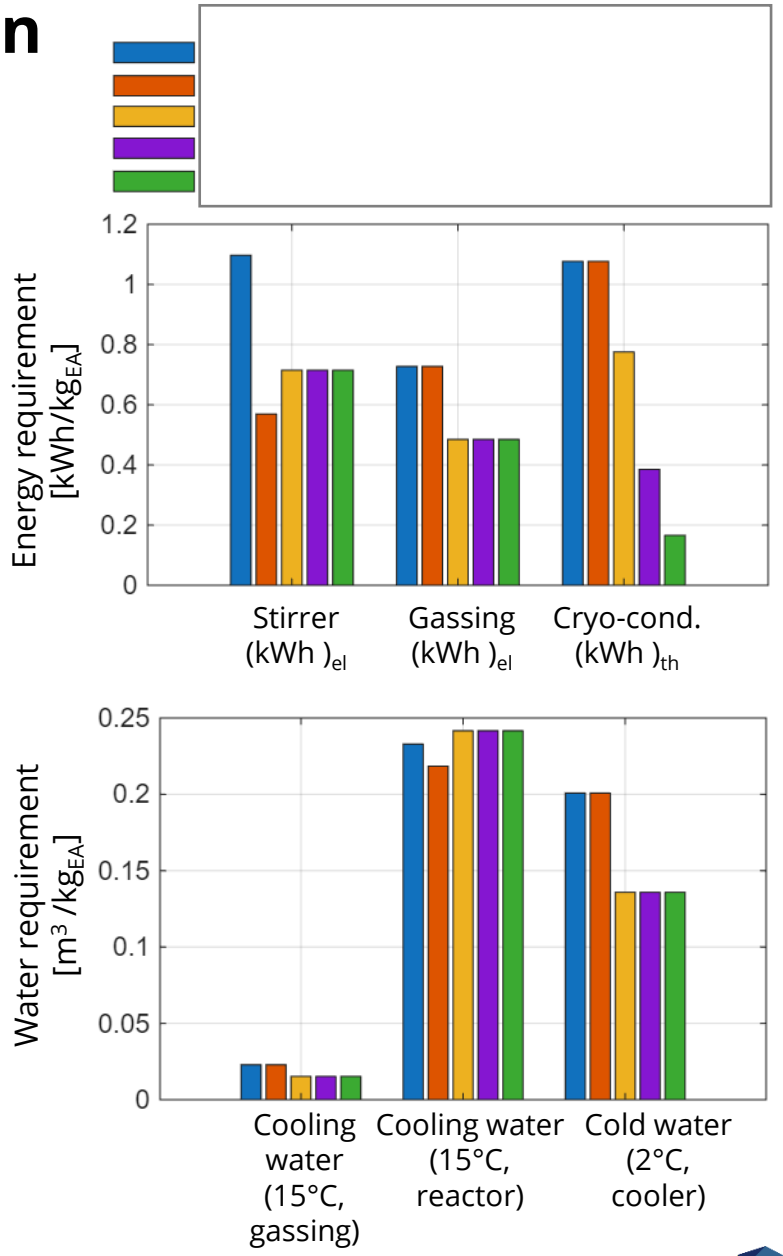


Process optimization of ethyl acetate production

Blue bars: Reference scenario (published)

In silico analysis of different process designs reveals potential for decreasing energy requirements.

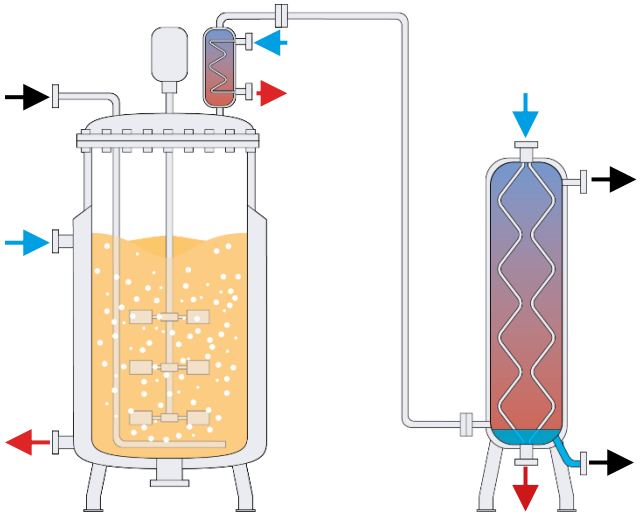


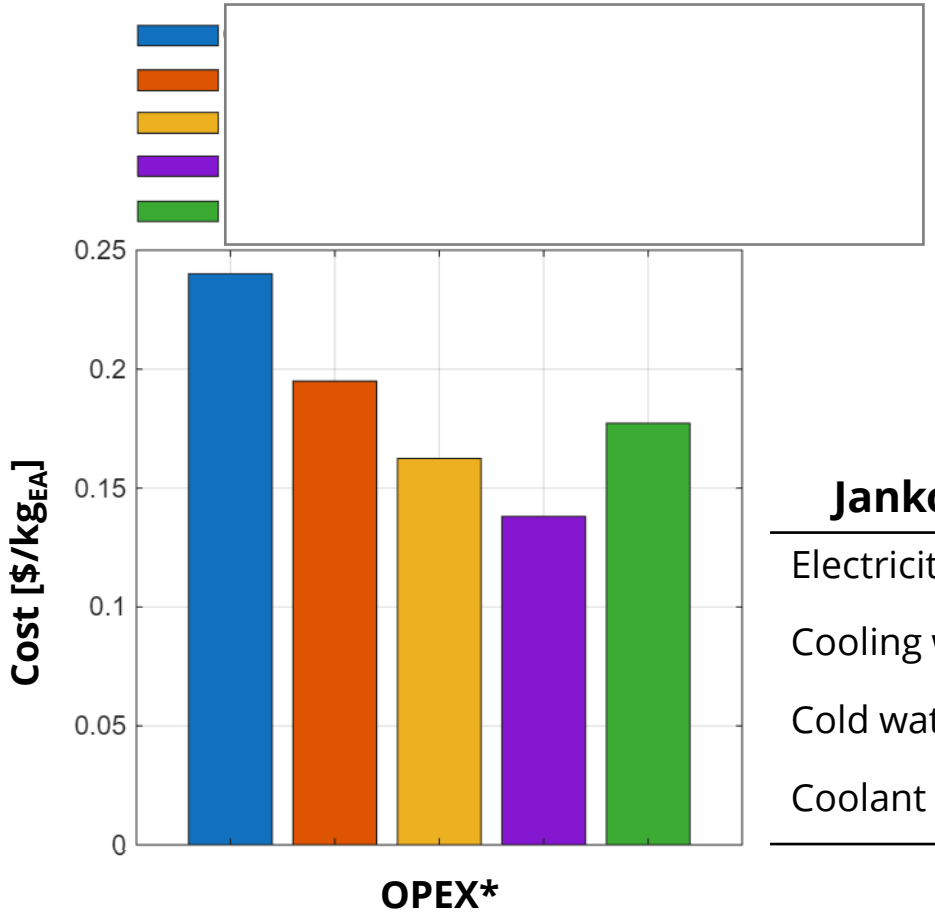


Summary & outlook

Repeated batch process with non-sterile molasses medium

Selling price of EthAc is 1.28 $/kg
(depends on global region)





Janković et al. (2025)	
Electricity	85.60 $/MWh
Cooling water	0.93 $/MWh
Cold water	11.68 $/MWh
Coolant	62.44 $/MWh

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-> Decoupling of final product concentration from initial sugar concentration.
-> 2G feedstocks containing dilute sugars can be valorised.

- Carbon efficiency is reasonable (0.35 g/g).
- Repeated batch fermentations are possible.
- Fermentation process can be non-sterile.
- Energy costs for product recovery are comparatively low.

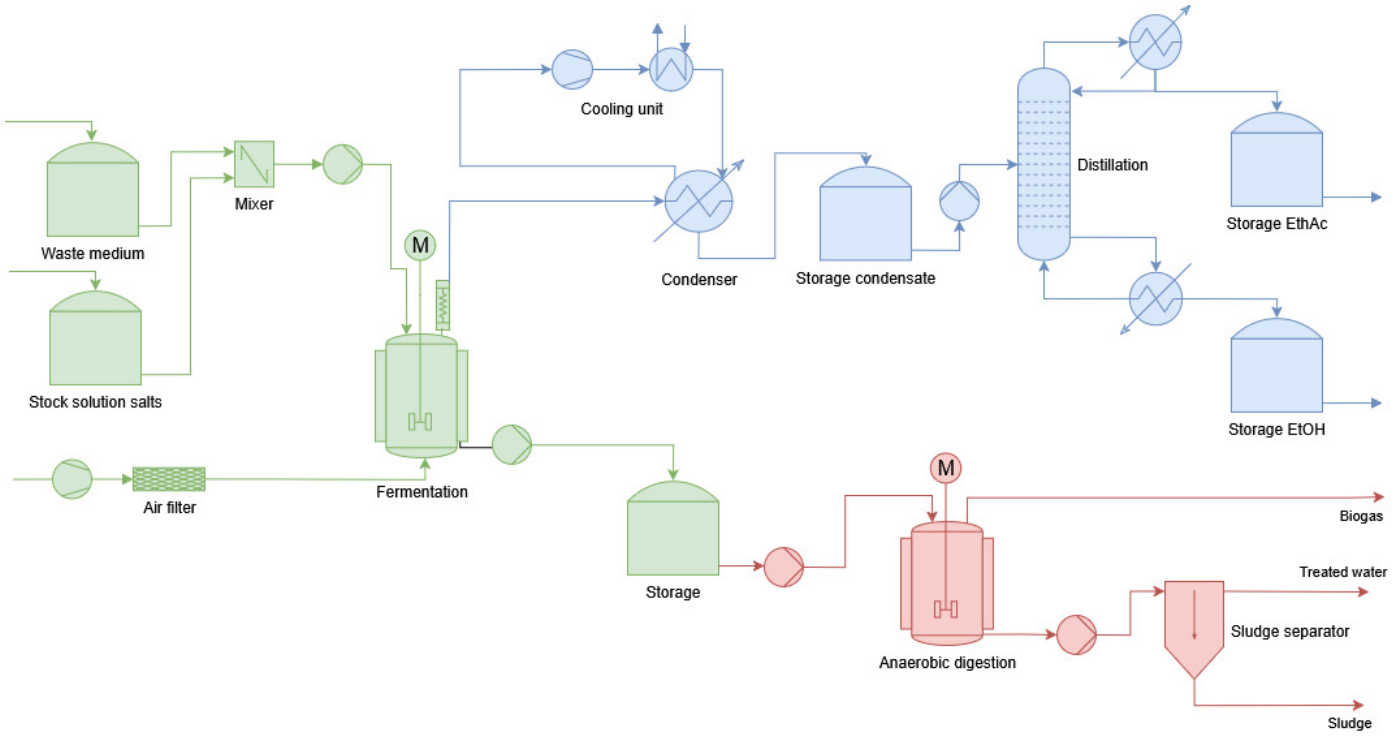
-> Profitable production process appears to be feasible...at least for waste sugars

Envisaged: Demonstration of technology at TRL6

Sächsische Aufbaubank finances construction of a mobile demo plant
(start 01/06/2025)

Objectives:

- Physical connection of all relevant unit operations
- Enabling of long-term repeated-batch fermentations
- Modular design to test different process variants
- Implementation in a mobile container for on-site testing
- Demonstration of technology at TRL 6



Acknowledgements

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Thank you for your attention

»Wissen schafft Brücken.«