HyPerFerment

MicroPro GmbH
Microbiological Laboratories
Magdeburger Str. 26b, 39245 Gommern

STREICHER Anlagenbau GmbH & Co. KG

Fraunhofer IFF

HyPerFerment II

Hydrogen from Biomass

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CMP 2023

Pilot-Scale & Industry session

Gefördert durch:

Bundesministerium für Wirtschaft und Klimaschutz

aufgrund eines Beschlusses des Deutschen Bundestages

MicroPro GmbH[1], Fraunhofer IFF[2] , HAW Hamburg[3] , TU Dresden[4] , Streicher Anlagenbau GmbH[5]

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The project

- Aims:
  - Microbial H_2 formation from natural substrates
  - Construction of 10 m³ pilot plant
  - Application of our concept at an existing biogas plant

- Project partner:

  MicroPro GmbH, Streicher Anlagenbau GmbH &Co. KG, Fraunhofer IFF

- End of project

  September 30, 2023

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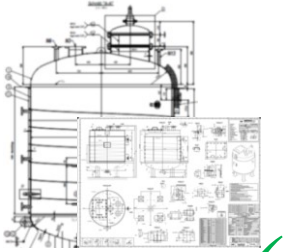
Time scale

HyPerFerment

KickOff
Oct 2020



Preconstruction ✓
Mar 2022

Essential parts still missing
Oct 2022

?

On-site Implementation
May 2023

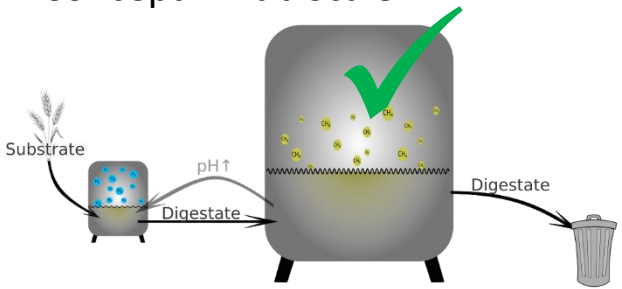
Nov 2021
Long Term Fermentation

30 L reactor: 100 L/d

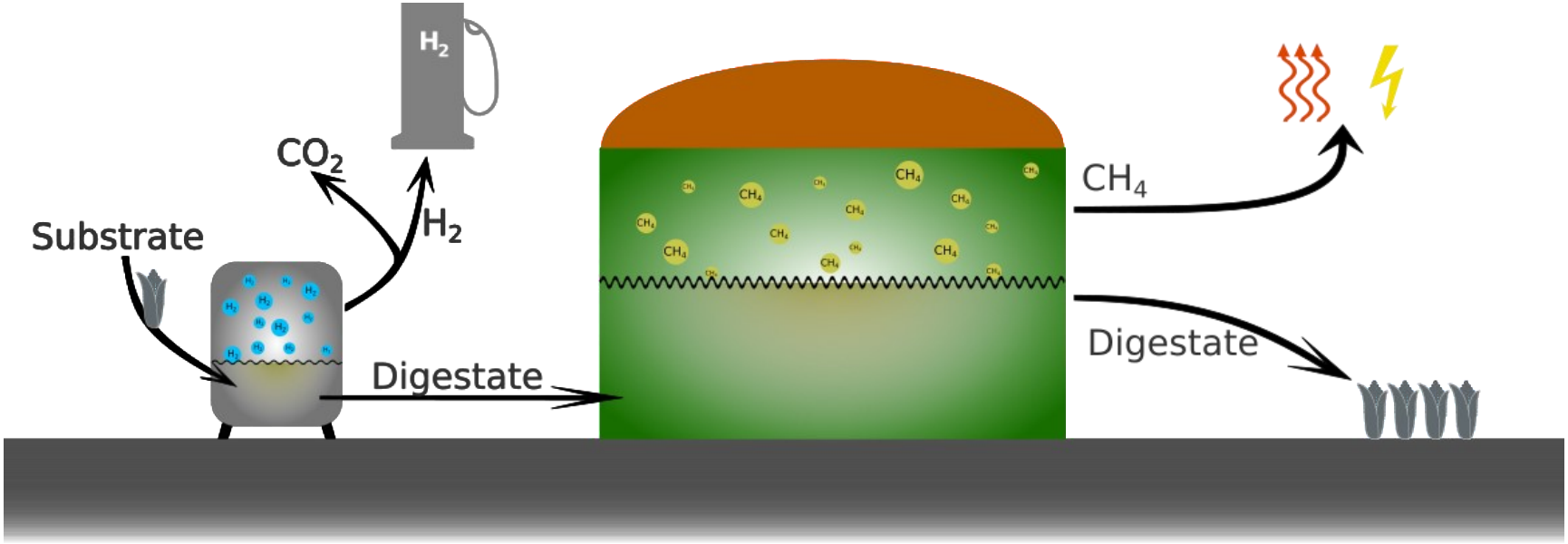
pilot plant: 3 kg/d
250 km/d

April 2022
Delivery Problems

Nov 2022
Concept in Lab Scale



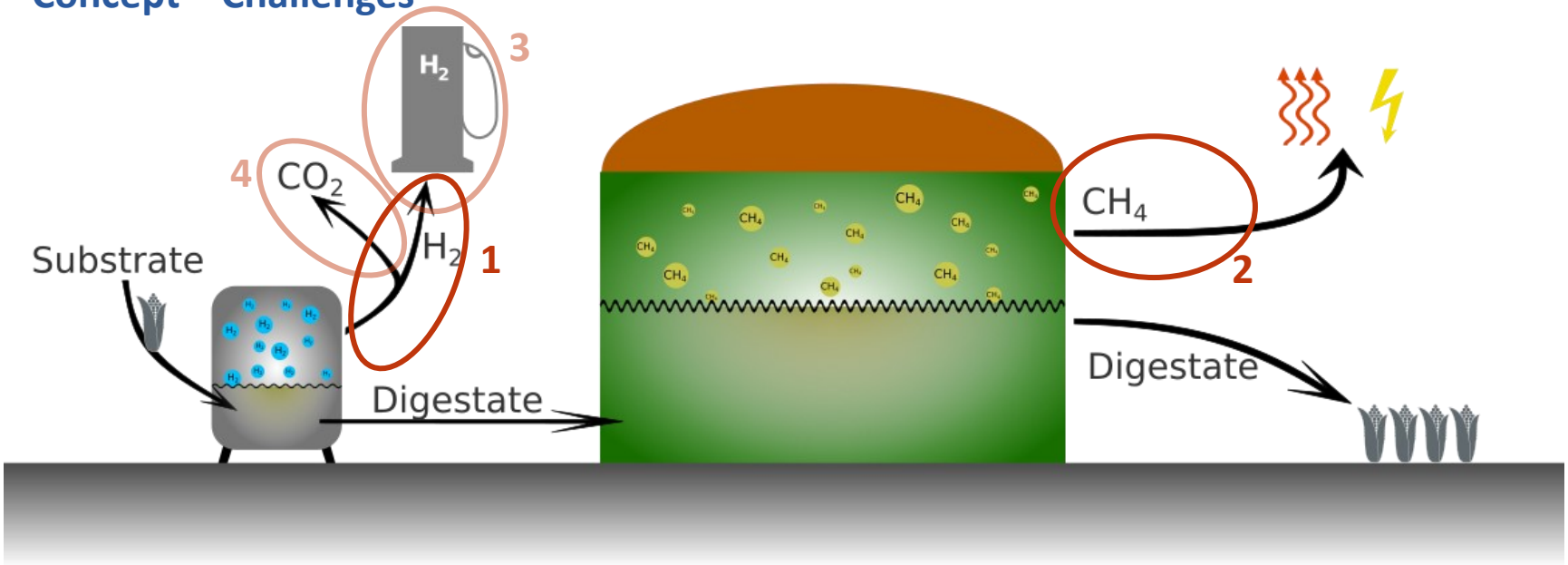
Concept



Advantages:

1) Use of established processes + infrastructure
2) Easy to apply
3) No loss in CH_4 yield despite H_2 production

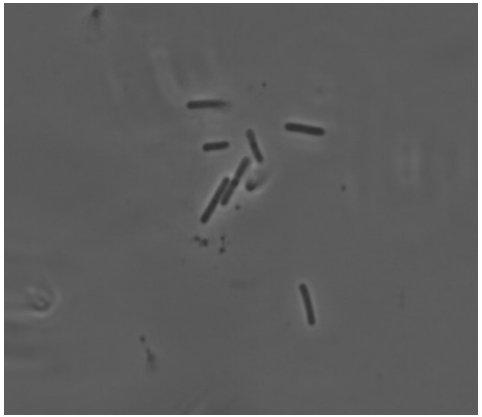
Concept – Challenges

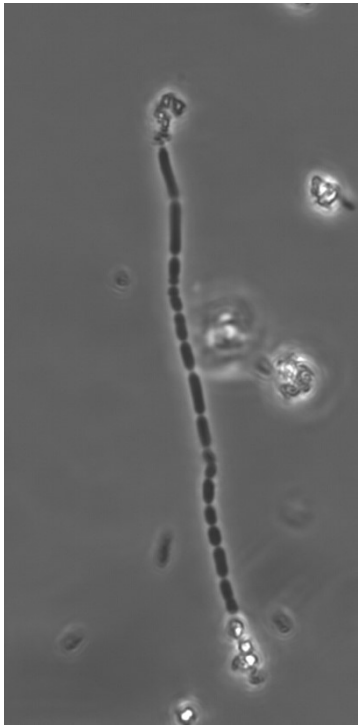


1 – H_2 formation 2 – Influence on CH_4 generation 3 – H_2 purification 4 – Use of CO_2

Cultures for H_2 formation

- > 30 isolates tested
- “Best” culture: 5H
  - Highly pH tolerable
  - Moderate thermophile
  - High substrate spectrum
  - „Pure culture“ (*in-silico*) as inoculate
  - Fast growth and high activity
  - No H_2S detectable
  - Gas composition: ≈ 55 % H_2 + ≈ 45 % CO_2





➡ **Very robust and reliable culture**

H_2 formation – Substrates

Substrates

Cheese whey ✓ (waste stream from diary industry

- Fed-Batch easily possible

~~Spent ground coffee~~

Molasses ✓ (sugar beet)

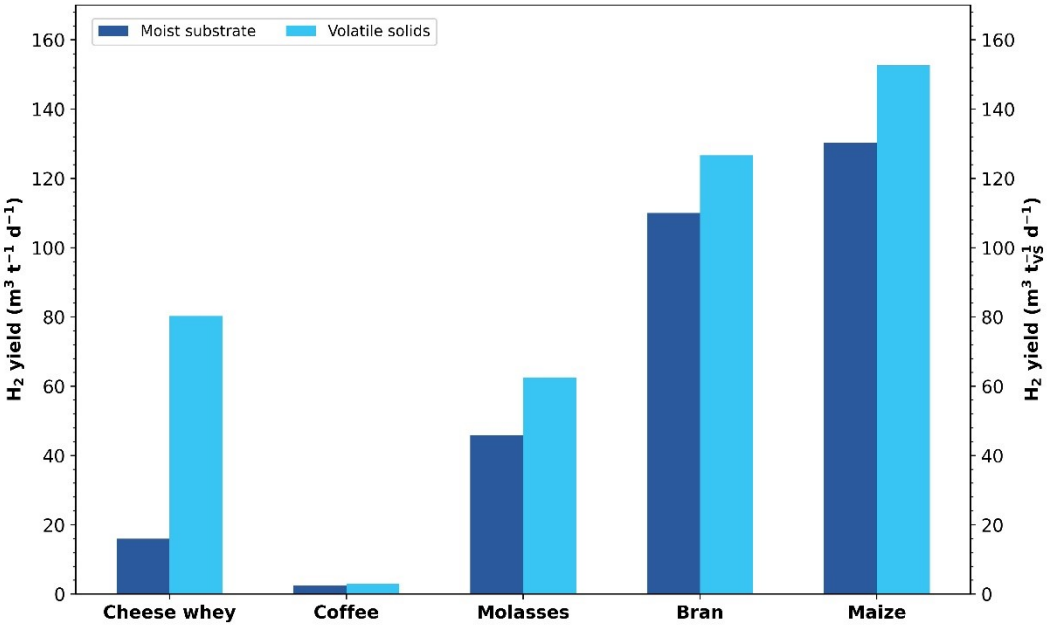
- Best for 1 L fermenter

Wheat bran ✓

- Best for 30 L fermenter

Maize silage ✓✓ ("standard substrate")

- Best yield of all tested substrates



➡ **Wide substrate variety with high yields**

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H_2 formation – Long-term fermentation

Experimental set-up

- 30 L bio reactor
- pH < 6.0, ϑ ≈ 60 °C
- Continuous feeding
- Substrate: wheat bran
- HRT: ≈ 3.3 d

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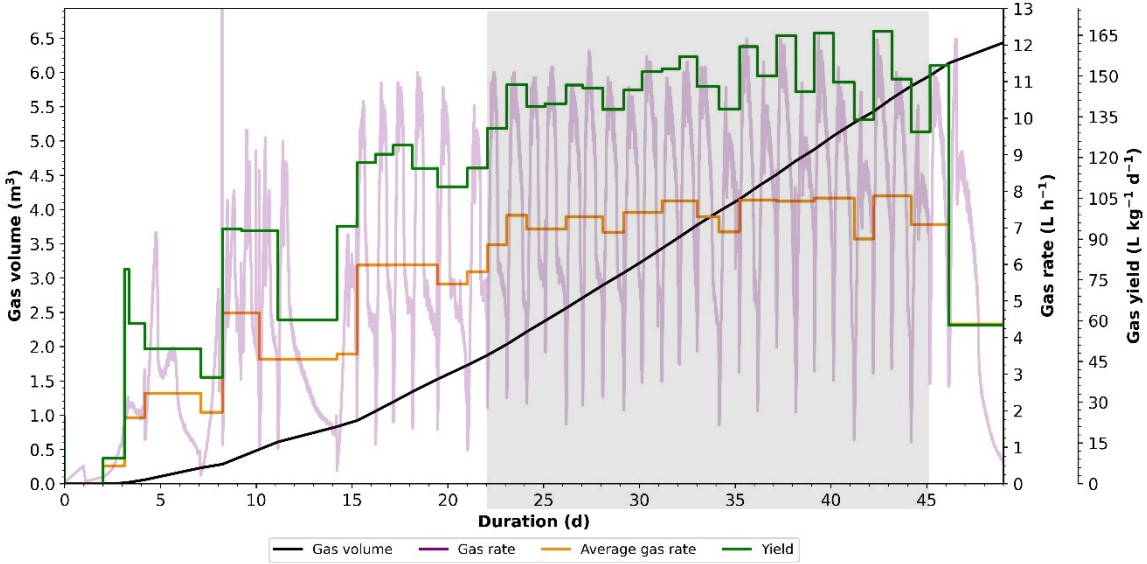
H_2 formation – Long-term fermentation

Experimental results

- 23 d run-time
  → ≈ 7x HRT
- 50 – 55 % H_2
  → 50 – 45 % CO_2
- ≈ 180 L_{biogas}/d
- ≈ 140 L_{biogas}/kg_{bran}
- ≈ 400 mg_{NaOH}/ L_{biogas}



➡ Pilot plant: 90 kwh/d

➡ **Stable process but further optimisation necessary**

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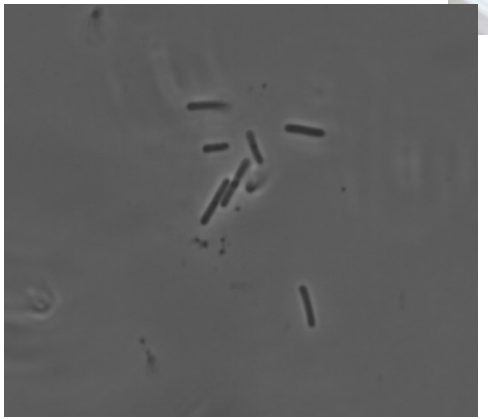
Influence of contaminants on H_2 formation

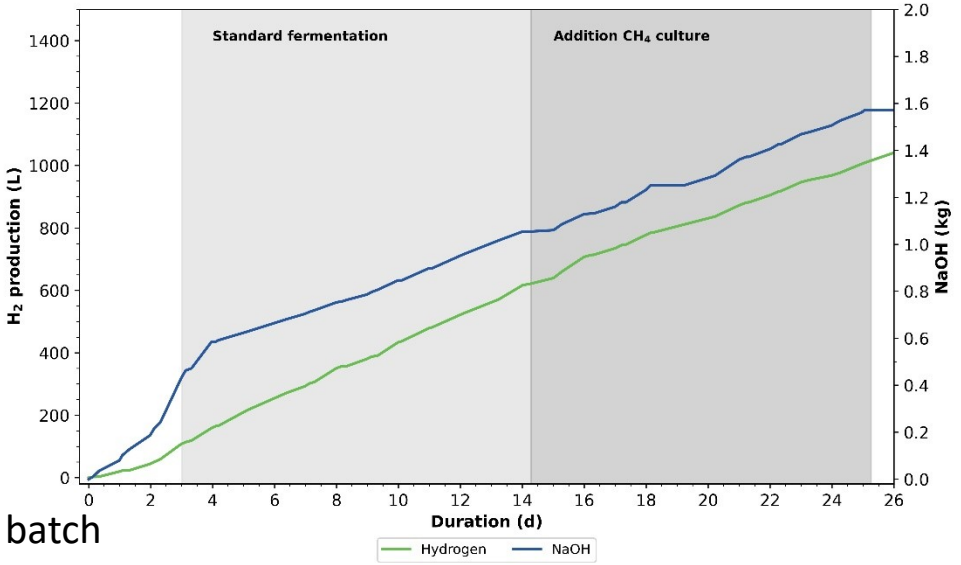
- Mould/ Atmospheric contaminants
  - Samples stored in open vessels for 21 d
  - Several batch assays afterwards

⇨ No decrease in H_2 production



Influence of contaminants on H_2 formation

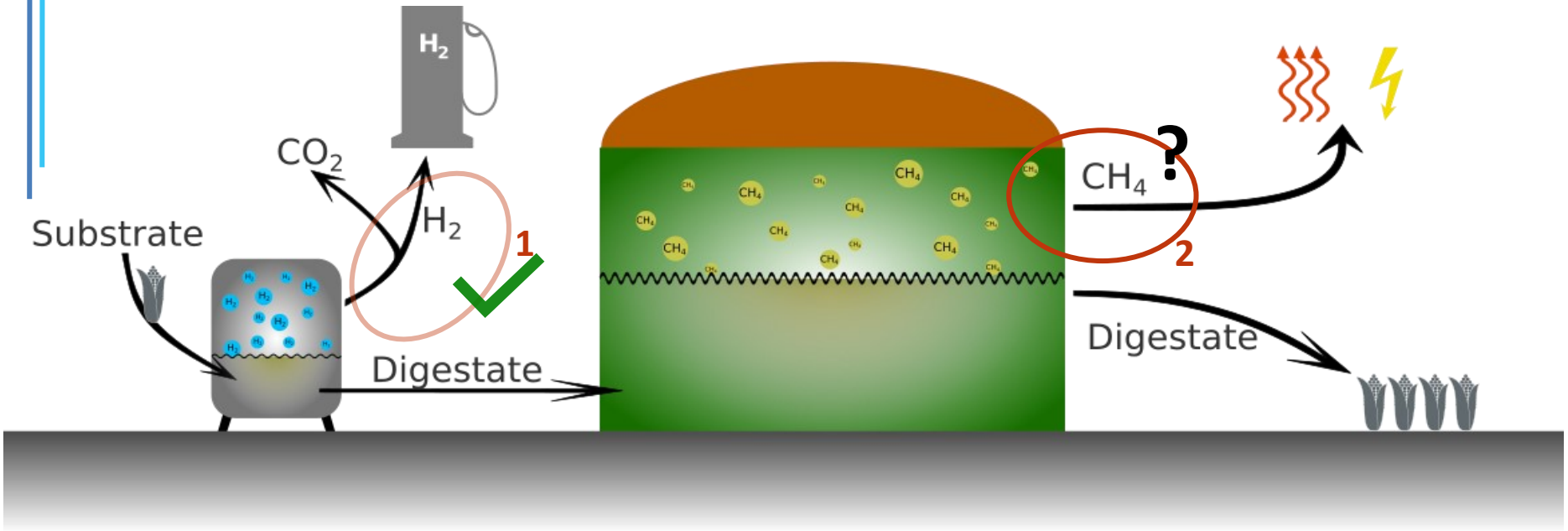
- Mould
  - ⇒ No decrease in H_2 production
- Methanogens
  - 30 L continuous fermentation of wheat bran
  - 10 d „standard“ fermentation
  - 10 d supplementation of 3 % (V/V) actively growing methanogens



- ⇒ No influence on H_2 formation rate
- ⇒ No methane detectable
- ⇒ No growth of methanogens in long-term batch

⇒ **Long-term contamination neglectable**

Challenge 1



1 – H_2 formation ✓

2 – Influence on CH_4 generation ?

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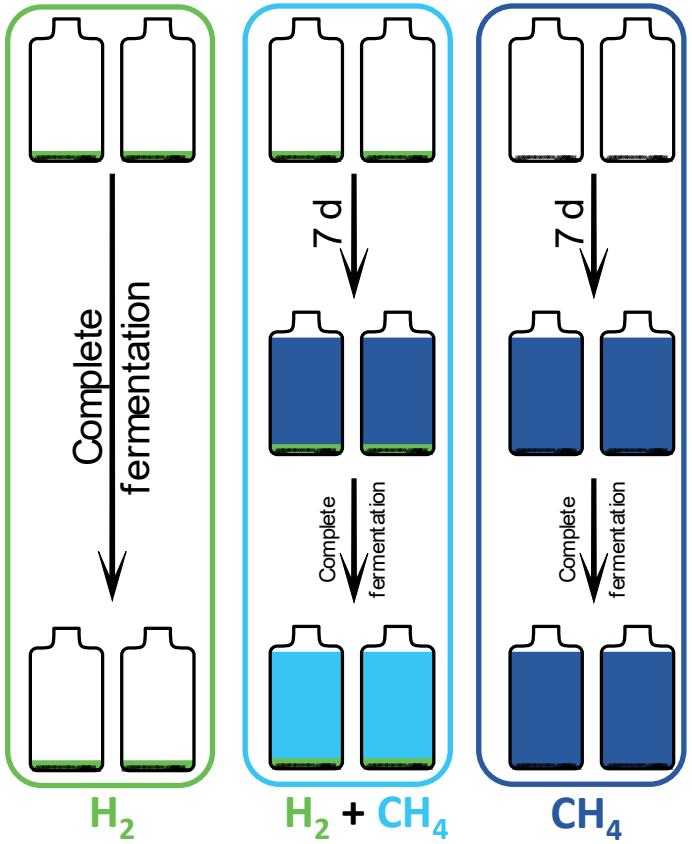
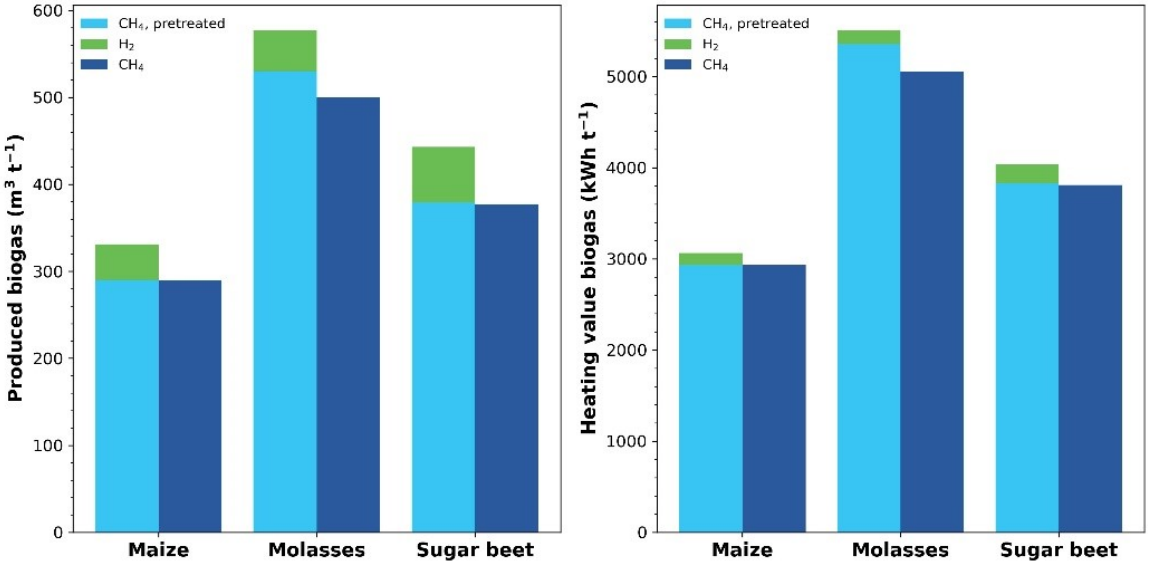
Influence on CH_4 formation

- Used substrates:
  - → Maize silage, molasses, sugar beet

- Experimental set-up:
  - → Complete fermentation by H_2 culture
  - → Fermentation by H_2 culture for 7 d → Addition CH_4 culture → complete fermentation
  - → Complete fermentation by CH_4 culture



Influence on CH_4 formation



- Comparably low heating value of the produced H_2
- **No negative influence** on CH_4 production

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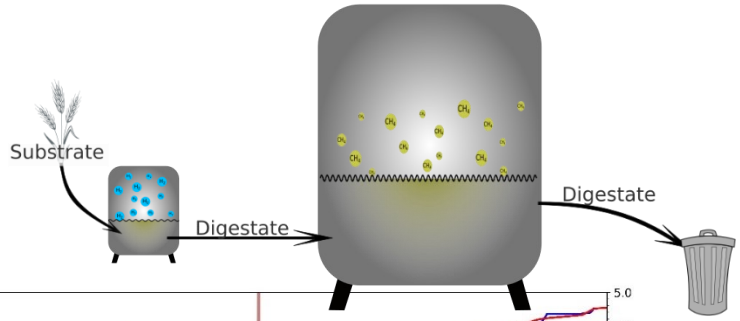
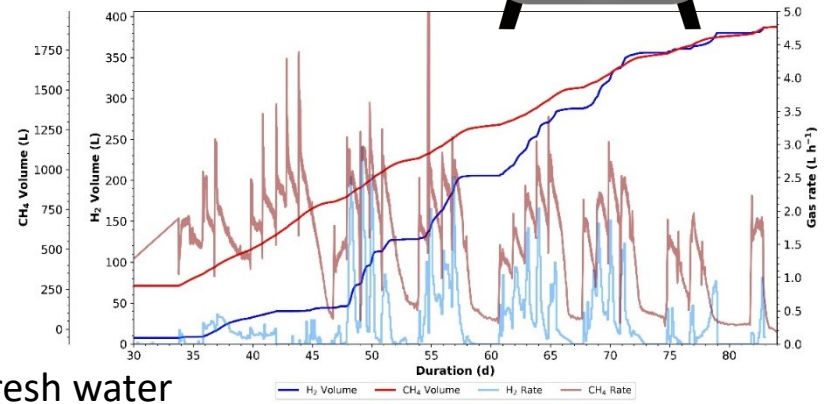
Lab scale test of the HyPerFerment concept

- Procedure
  - 3 L H_2 fermentation from wheat bran
  - 30 L CH_4 fermentation of H_2 digestate
  - No regular water or NaOH addition

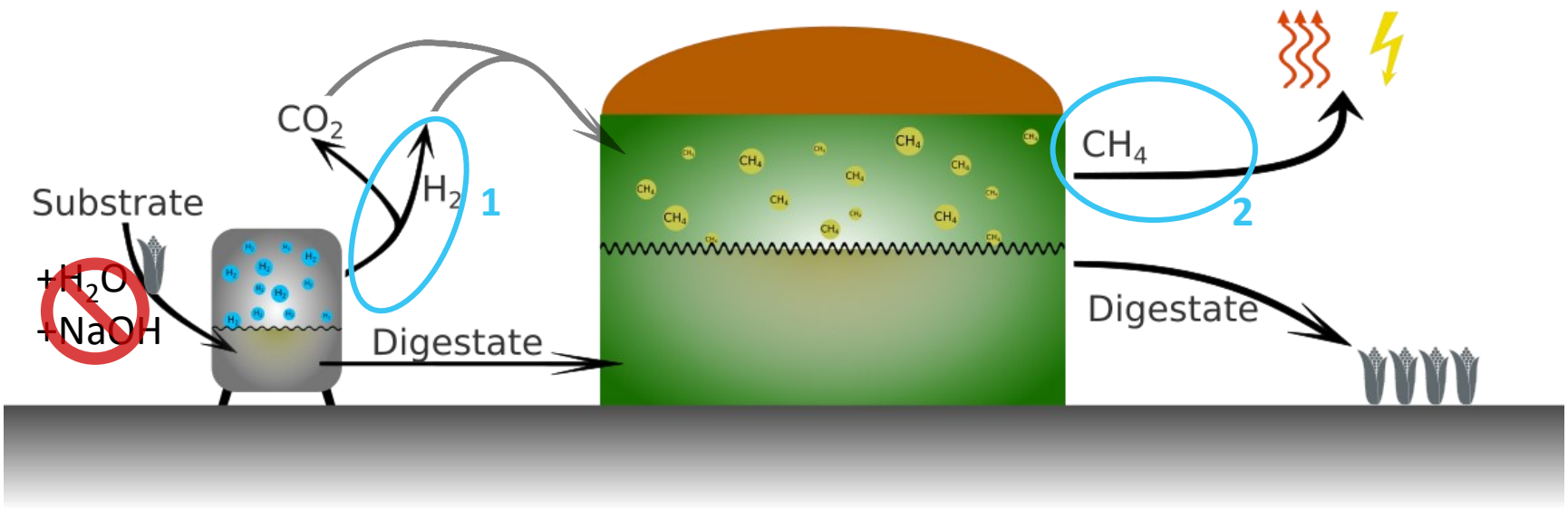




➡ Processes **not yet** optimised
➡ No cross contamination
➡ Significant reduction of NaOH and fresh water

➡ **H_2 fermentation applicable in "real" processes**

Conclusion



1 – H_2 formation ✓

2 – Influence on CH_4 generation ✓

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Conclusion & Outlook

- H_2 formation easily possible
- Wheat bran and maize silage very suitable substrates
- Very robust process with approx. 55 % (V/V) H_2
- No negative influence on CH_4 production by previous H_2 formation
- Construction and implementation of 10 m³ pilot plot until ~~Q2 2022~~ Q2 2023
- Evaluation of the process by means of physical optimum
- Potential evaluation and optimisation for future industrial applications

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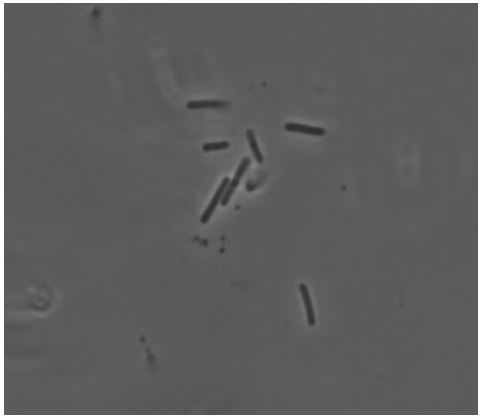

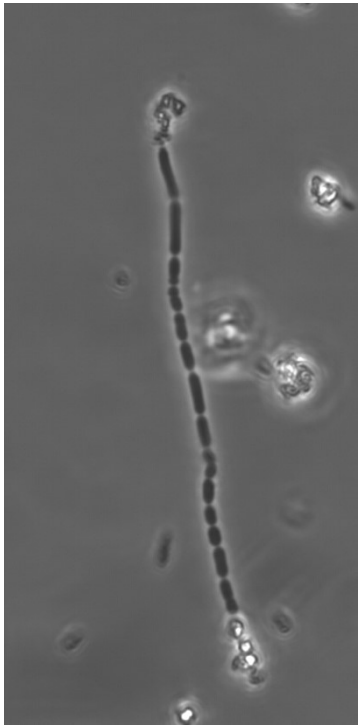

➡ **Very robust and reliable culture**

Literature comparison