HyPerFerment

MicroPro GmbH
Microbiological Laboratories
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HyPerFerment II

Microbial Process Development and Evaluation of a Fermentative Hydrogen Production Pilot Plant

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Gefördert durch:

Bundesministerium für Wirtschaft und Klimaschutz

aufgrund eines Beschlusses des Deutschen Bundestages

VAAM 2022

Mini symposium
Next generation biotransformation

MicroPro GmbH[1], Streicher Anlagenbau GmbH[2], Fraunhofer IFF[3]

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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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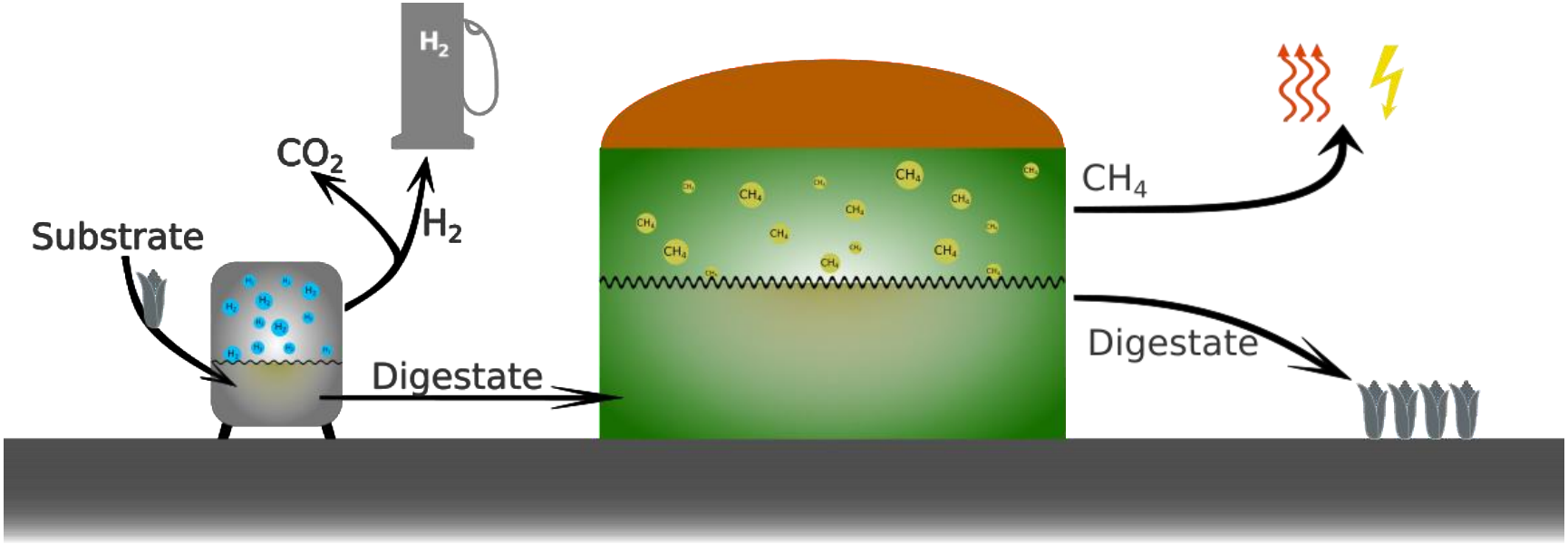
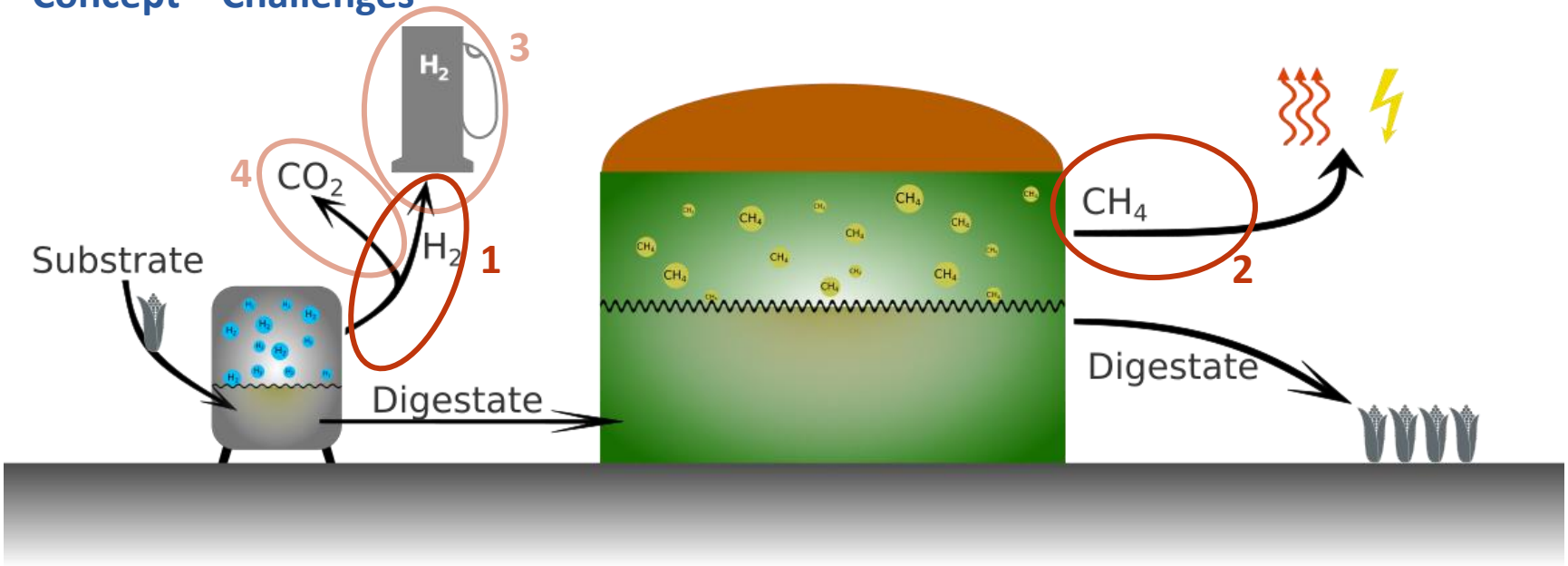
Concept



⇒ **Construction and implementation planned for May 2022**

⇒ **In cooperation with BALANCE Erneuerbare Energien GmbH**

Concept – Challenges



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

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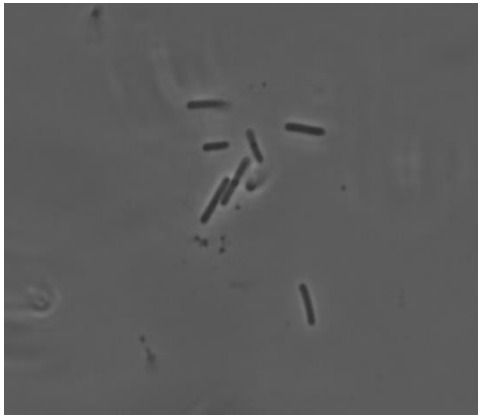
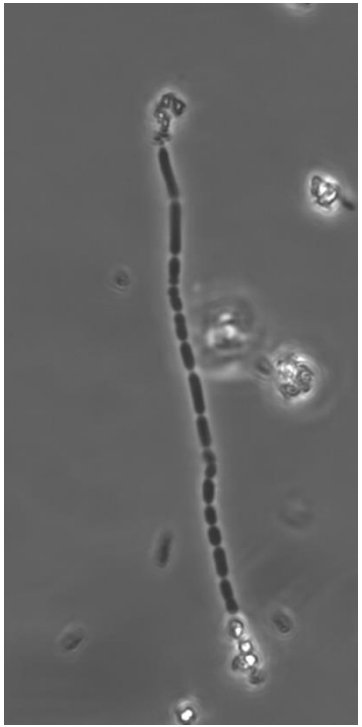
Cultures for H_2 formation

- > 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**

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H_2 formation – Substrates

Substrates

Cheese whey ✓ (waste stream from diary industry

- Fed-Batch easily possible

~~Spent ground coffee~~

Molasses ✓ (sugar beet)

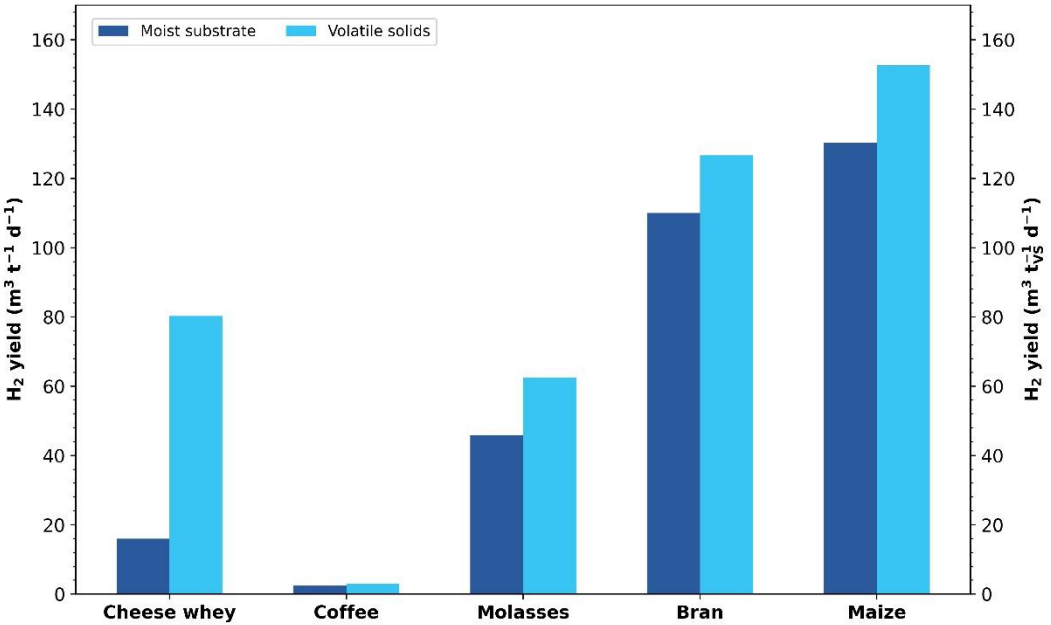
- Best for 1 L fermenter

Wheat bran ✓

- Best for 30 L fermenter

Maize silage ✓✓ ("standard substrate")

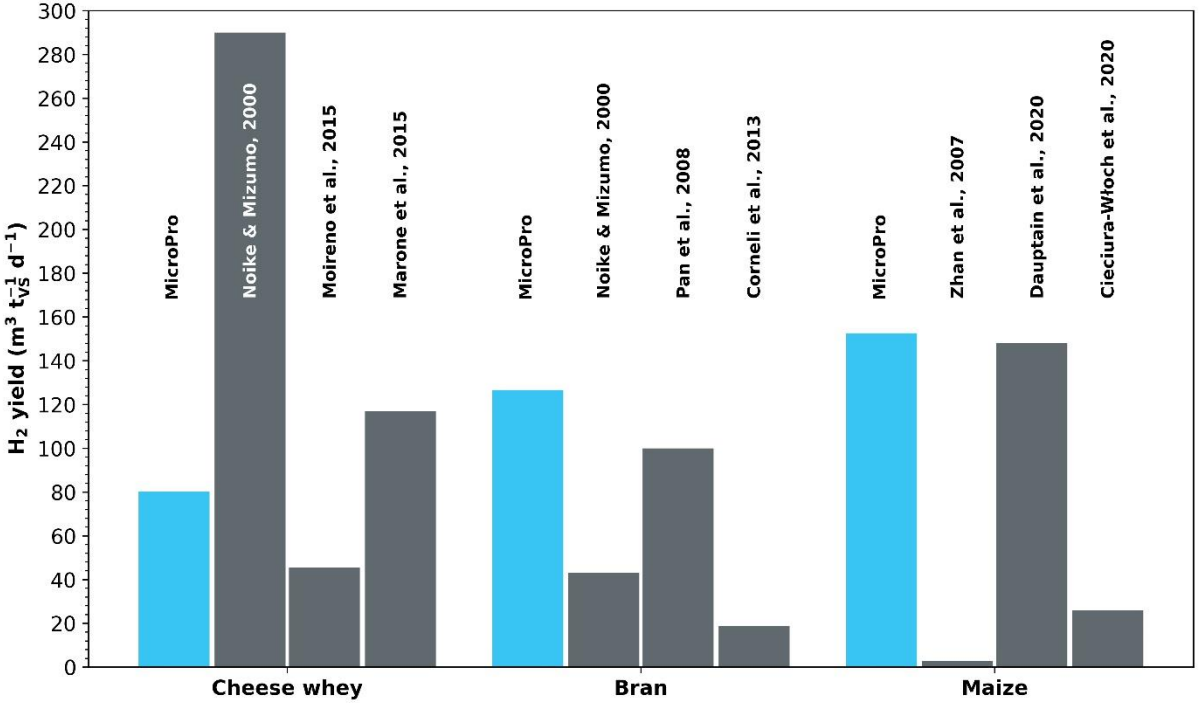
- Best yield of all tested substrates



To-do: Straw, brewer's spent grain, pomace

⇒ **Wide substrate variety with high yields**

Literature comparison



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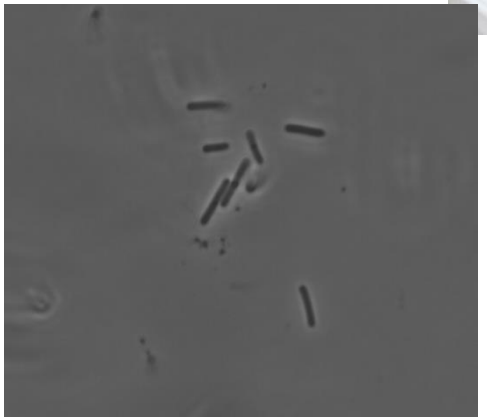
Influence of contaminants on H_2 formation

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

⇨ No decrease in H_2 production



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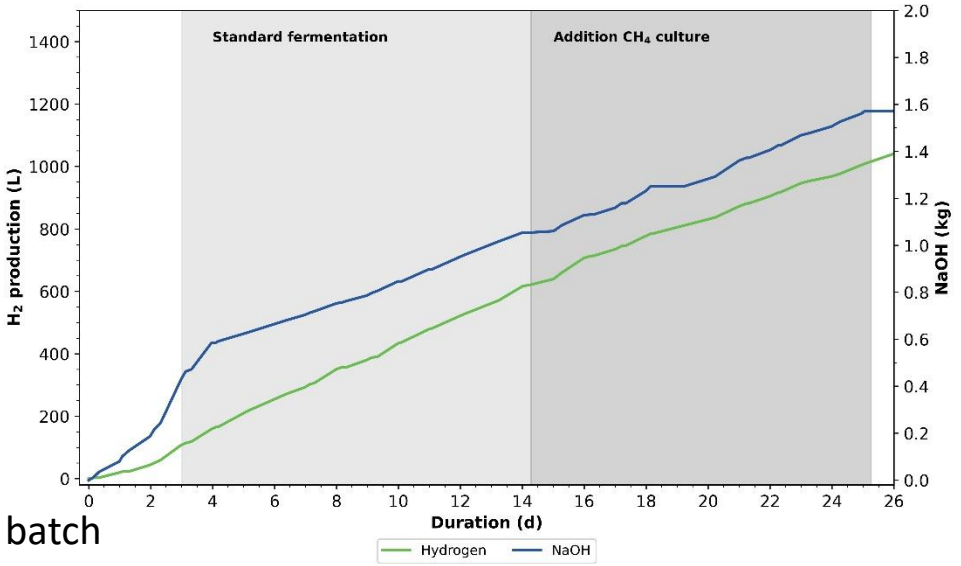
Influence of contaminants on H_2 formation

- 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

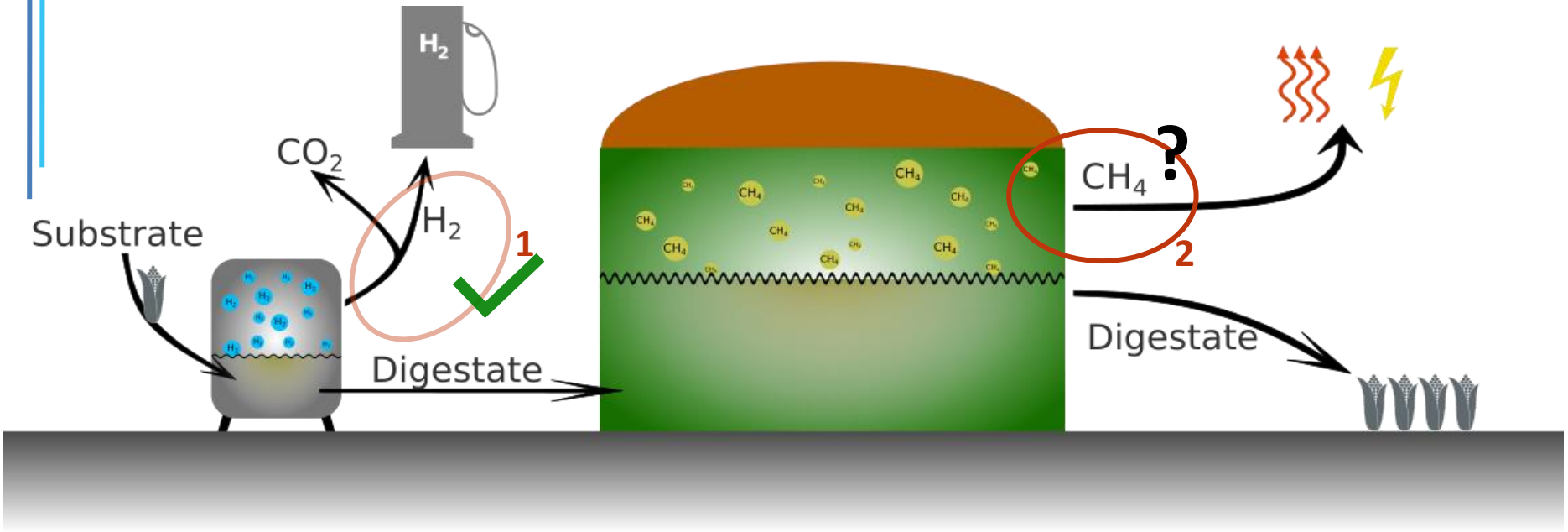


➡ Slightly decreased H_2 formation rate

➡ No methane detectable

➡ No growth of methanogens in long-term batch

➡ **Long-term contamination neglectable**



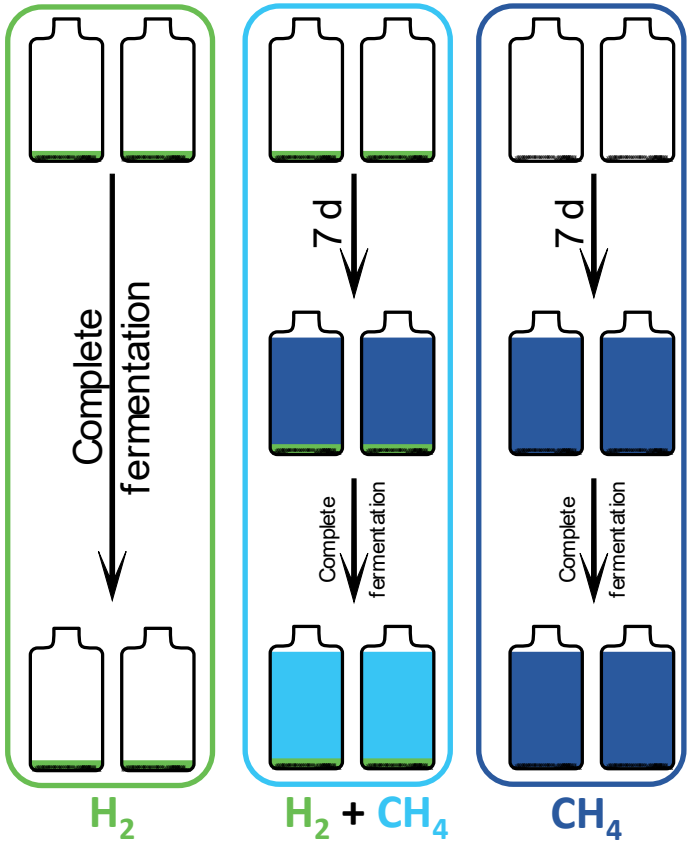
1 – H_2 formation ✓

2 – Influence on CH_4 generation ?

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



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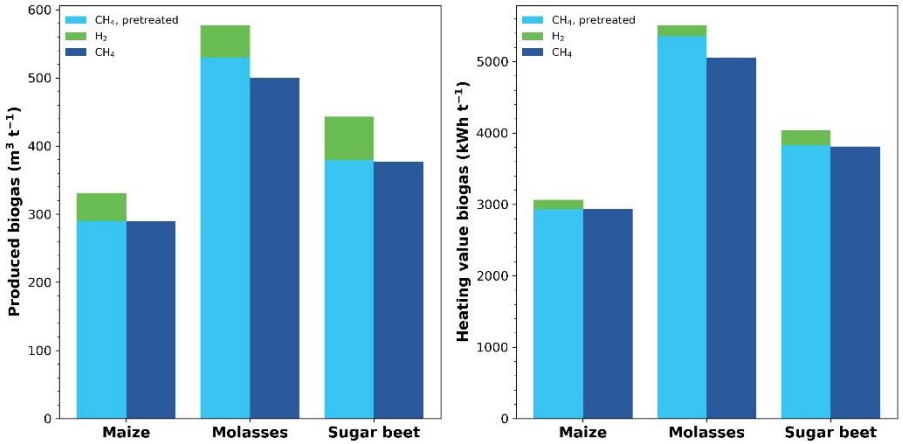
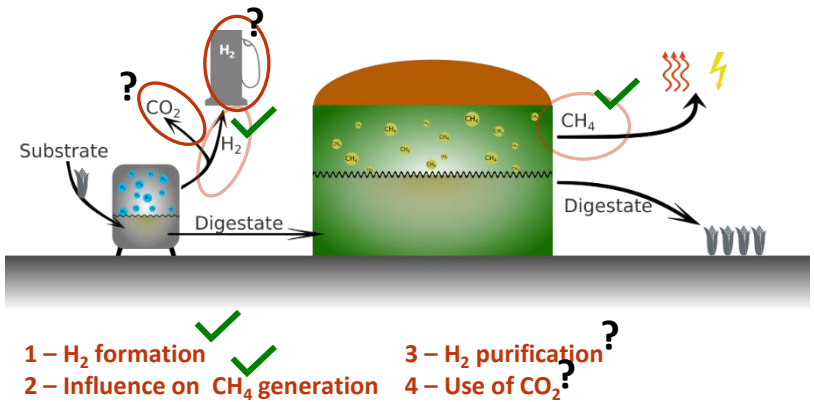
Influence on CH_4 formation





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

➡ Comparably low heating value of the produced H_2

➡ **No negative influence** on CH_4 production

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H_2 formation – Long-term fermentation

Experimental set-up

- 30 L bio reactor
- pH ≈ 5.5, ϑ ≈ 60 °C
- Continuous feeding
- Substrate: wheat bran
- HRT: ≈ 3.3 d

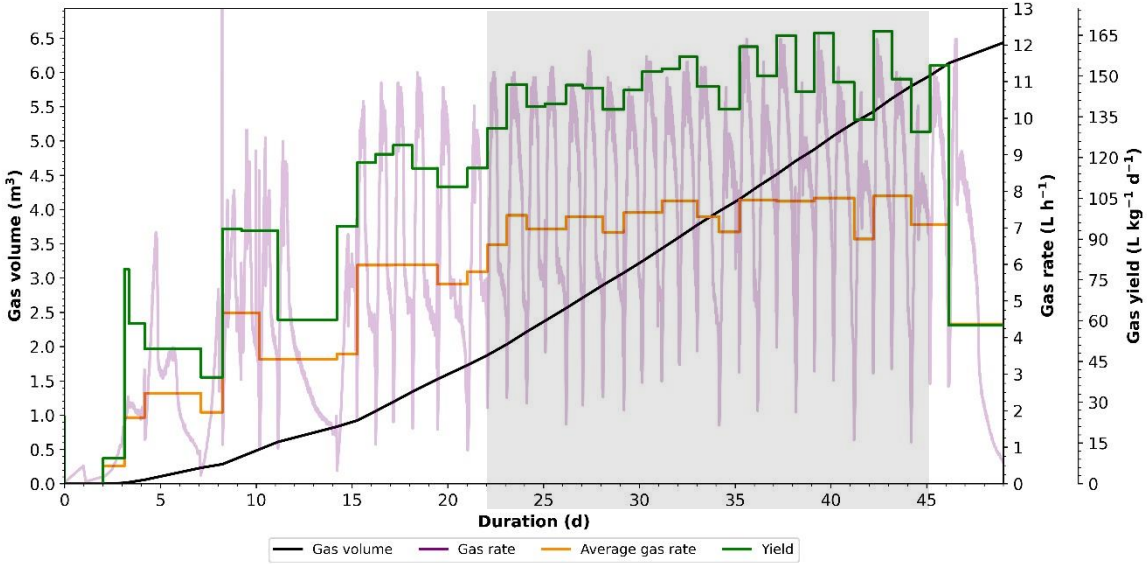
H_2 formation – Long-term fermentation

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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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
- Evaluation of the process by means of physical optimum
- Potential evaluation and optimisation for future industrial applications

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