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Biomethane Production from Gaseous Substrates Using Methanogenic Archaea

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Introduction

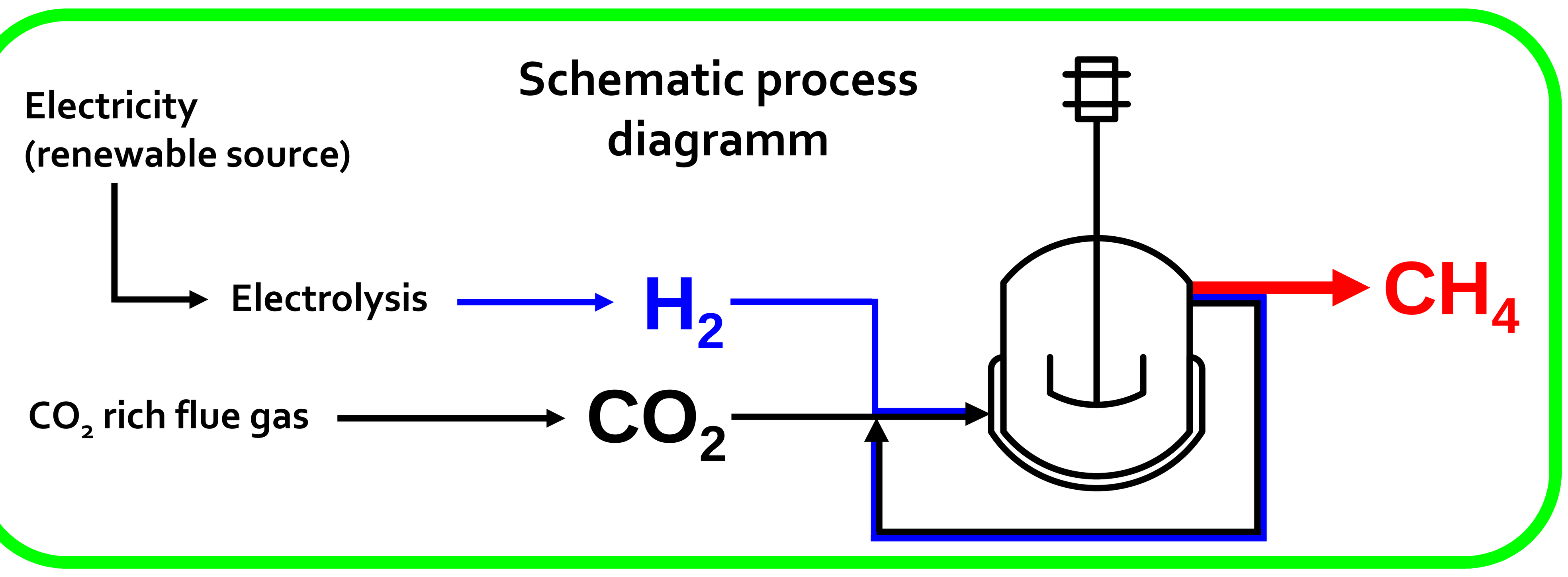
World wide concerns about climate change and the foreseeable end of fossil energy resources demand the development of renewable and CO_2 neutral processes for energy production. Regarding these topics, a promising process is the conversion of exhaust CO_2 and H_2 into biomethane (CH_4) by methanogenic archaea. This simple one step biological process can be used for a variety of different applications, such as:

- storage of electricity from renewable sources
- enhancement of biogas methane content
- conversion of CO_2 rich industrial flue gasses into CH_4
- safe biochemical hydrogen storage via conversion to methane

Goals

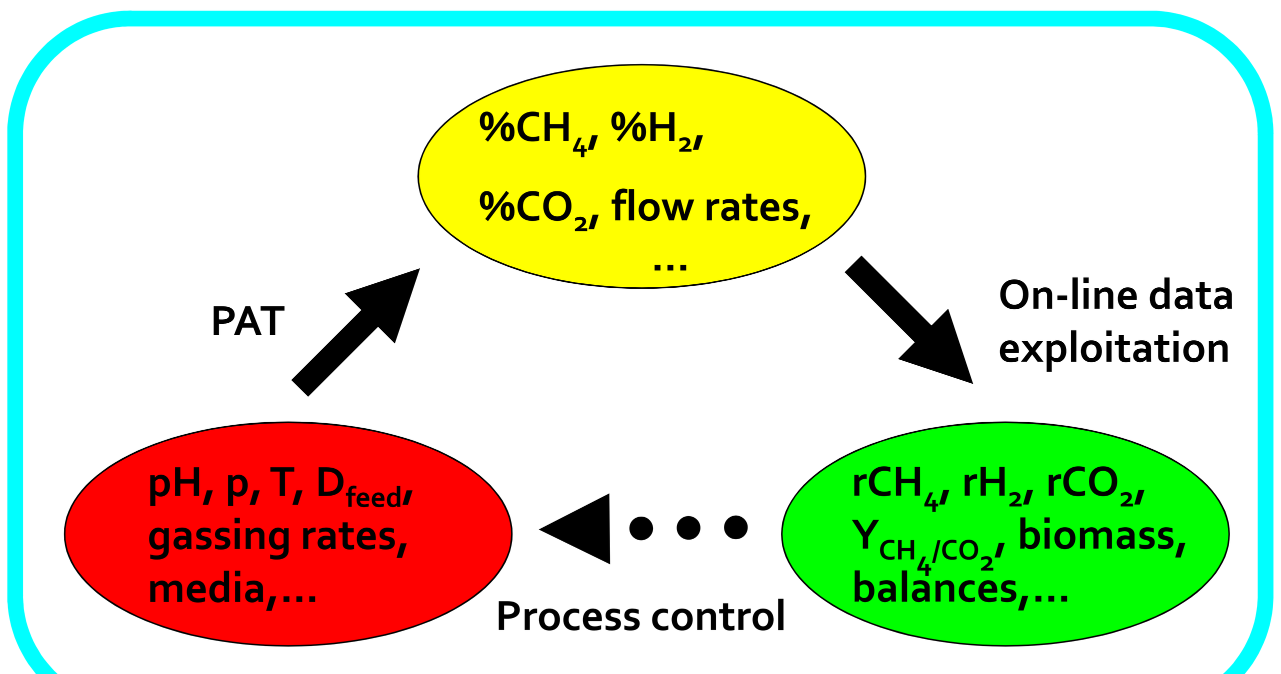
- selection of promising microbial strains for efficient methane production
- quantification of the process performance using PAT methods
- qualitative and quantitative performance studies with industrial exhaust gases
- maximising CH_4 production, product quality and process stability by optimizing process parameters and conditions, reactor design and control
- successful scale-up of the process to pilot-scale

Schematic process diagramm



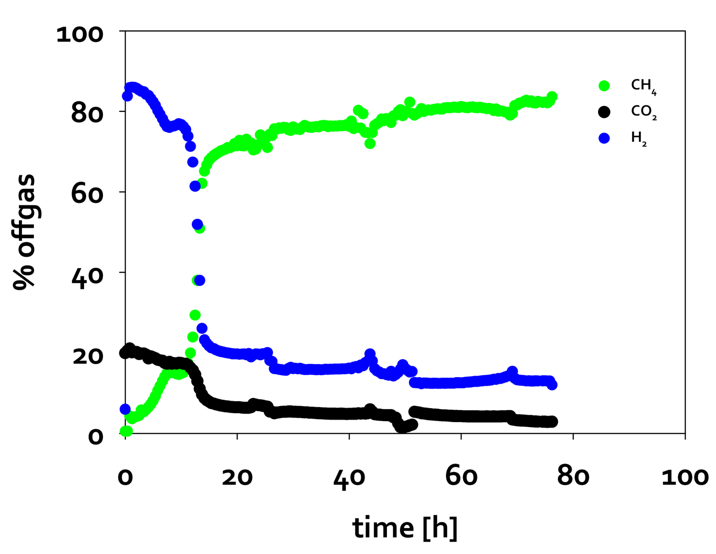
Methods

- Continuous anaerobic culture
- Monoculture on defined liquid medium
- Integrated process setup: Lucullus PIMS, on-line measurements, process automatisation
- On line data exploitation: rates and yields, metabolic balancing, on-line error test, online data reconciliation

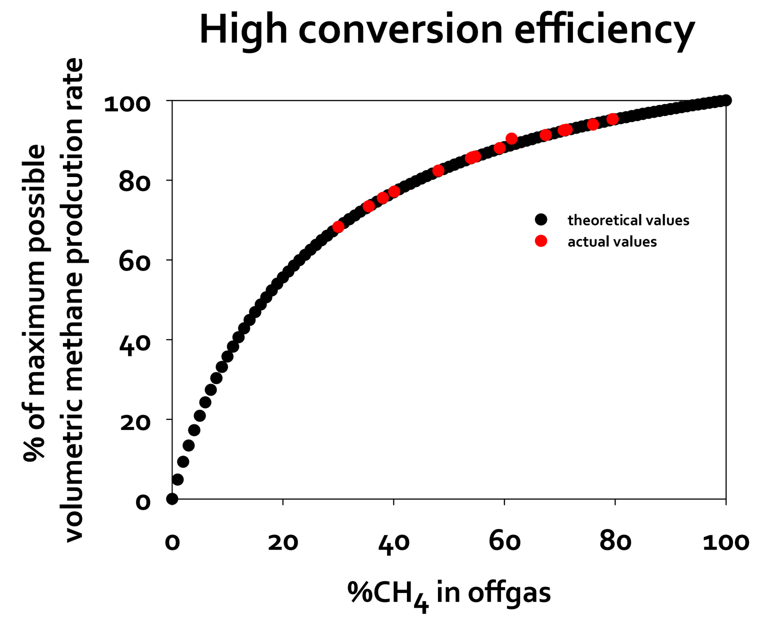


$$r_{CO_2} \cdot CO_2 + r_{H_2} \cdot H_2 \rightarrow r_x \cdot biomass + r_{CH_4} \cdot CH_4 + r_{H_2O} \cdot H_2O$$

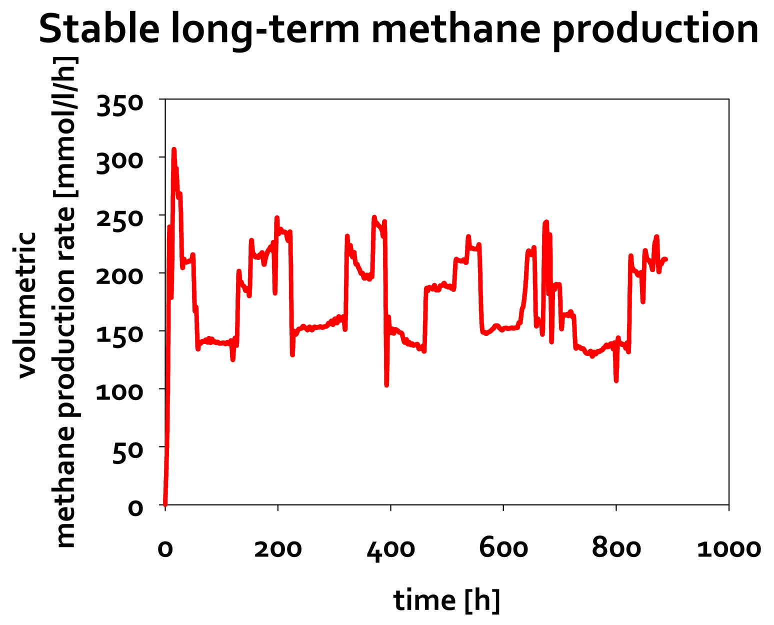
High methane content



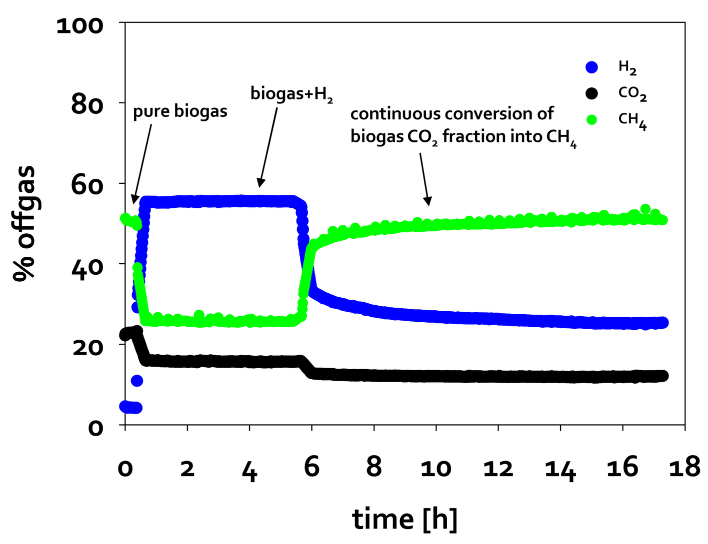
High conversion efficiency



Stable long-term methane production



Successful biogas upgrading



Results

Until now, long-term stability (>1000h continuous methane production) and high conversion efficiency (>95% of theoretical yield) under ideal process conditions have been proven and some critical parameters for the enhancement of volumetric and specific conversion rates have been identified.

This already led to successful improvements of the overall process performance and will be a crucial part of the ongoing research.

First real gas applications have been carried out successfully. Raw biogas with a high CO_2 content was used as carbon source for the process resulting in an effective conversion towards methane.

The tolerance of the system against the most common exhaust gas components (e.g. O_2, CO, SO_2) is in progress, in order to increase the variety of gases that can be used as educts for methanogenesis.

Advantages

- fast one step methane production
- biological process, thus moderate process parameters
- independence from biomass as raw material and therefore no competition with land for food production (4th generation)
- direct use of exhaust CO_2 from various industrial processes as carbon source for methane production
- continuous process operation mode

Conclusion

- The presented process proves good performance in terms of conversion efficiency and long term stability, two parameters essential for an industrial application.

- The applied methods enabled fast and easy process characterisation and development. The volumetric productivity was already drastically enhanced, proving the process production capacity for industrial conversion.

- The obtained results, together with the broad range of applications and the variety of possible substrates, make this process a promising candidate for an important role in the 21st century energy policy.

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