Sustainability and Life Cycle Assessment of feedstock digestion systems

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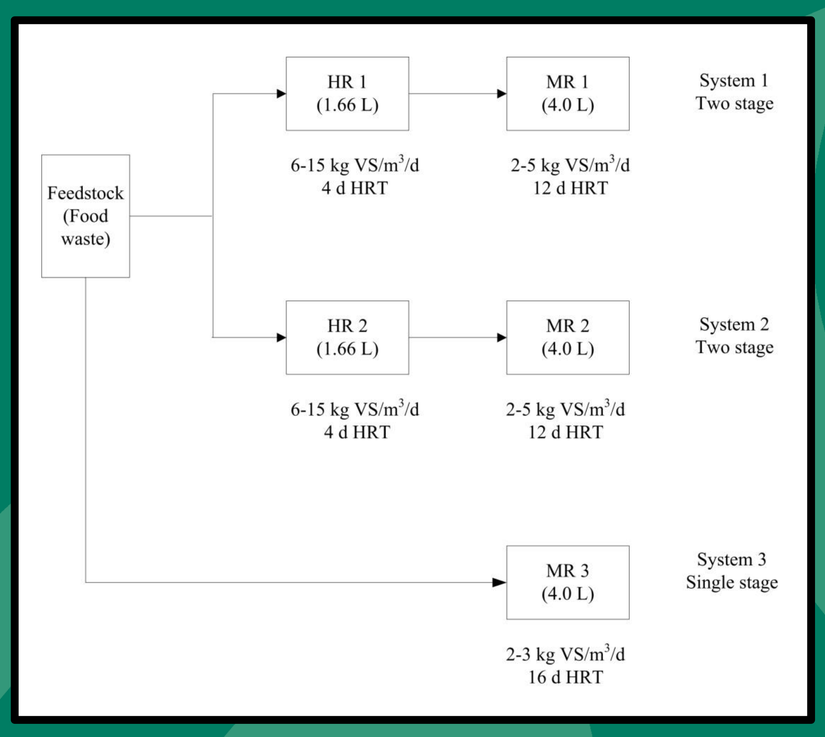
Introduction

This project will assess innovative biogas technologies. This will be carried out through detailed systems analysis including for energy and carbon balances, laboratory assessment, cost analyses and general life cycle analyses (LCA).

Multi-phase digestion

The purpose of this study is to investigate the methane potential in a 2-phase fermentation process based on food waste. The first phase comprises an acidifying hydrolytic phase, producing hydrogen and carbon dioxide. The second phase is dominated by the methanogenic phase, generating higher concentrations of methane compared to a single-phase system.



The main objective of this experiment is to evaluate the performance of an innovative 2-phase reactor system at high loading rates (OLR) and short retention times (HRT). The efficiency of these systems is compared to a one phase reactor system subjected to the same conditions.

Highlights:

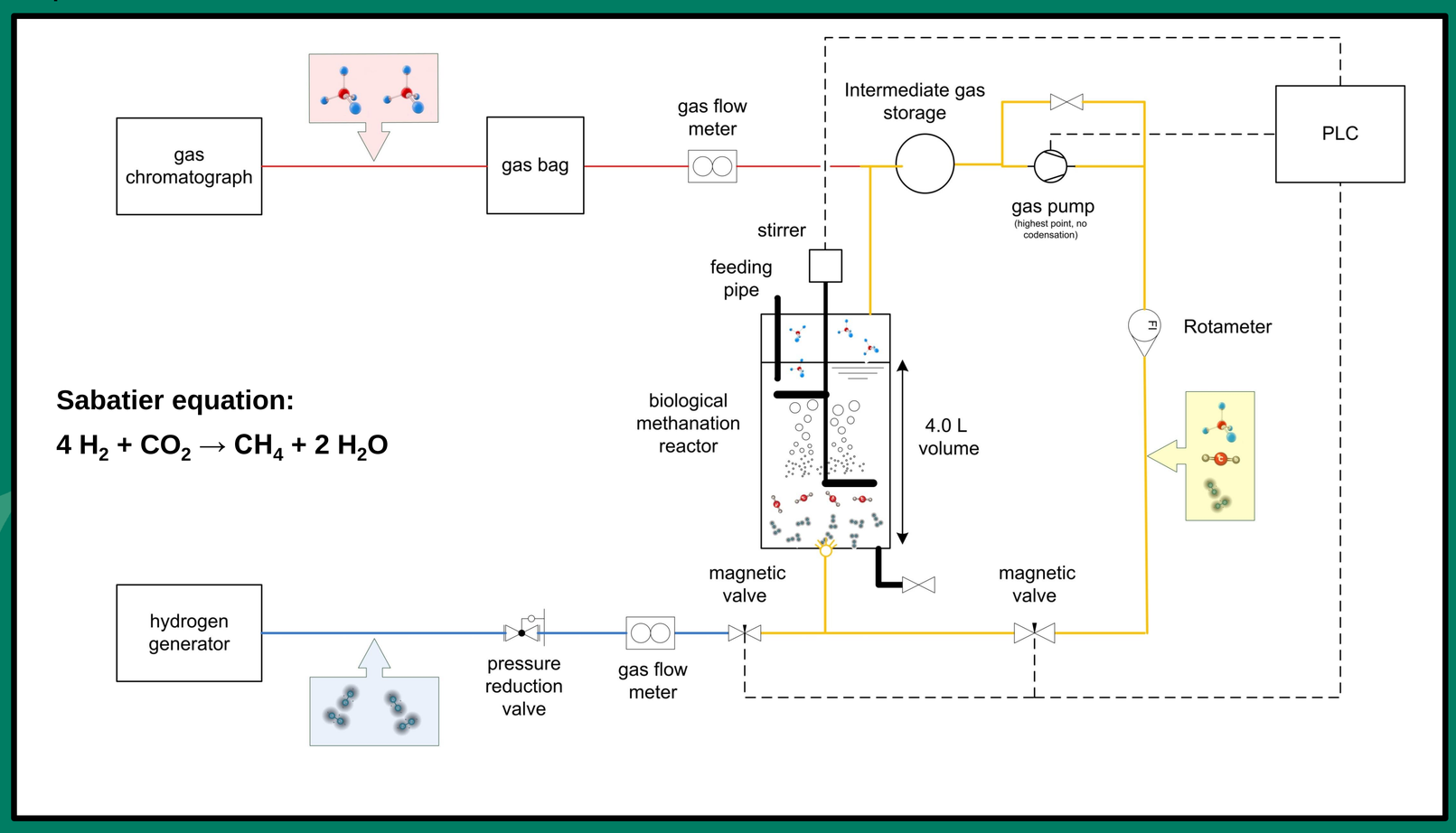
- Evaluation of high OLR on SMY
- Hydrolysis performance and impact of different OLR on the hydrolysis reactor
- Impact of trace element supplementation
- Compare efficiency (carbon- and energy balance) of 2-phase system, 1-phase System, BMP, Buswell

Biological methanation

Strategy

One of the major research tasks is to draw and compare different scenarios of innovative biomethane systems with life cycle assessment.

This biological methantion project focuses on efficient digestion systems and upgrading of biogas with external hydrogen from surplus electricity as described in the Sabatier equation.



Sabatier equation:

$4\ H_2 + CO_2 \rightarrow CH_4 + 2\ H_2O$

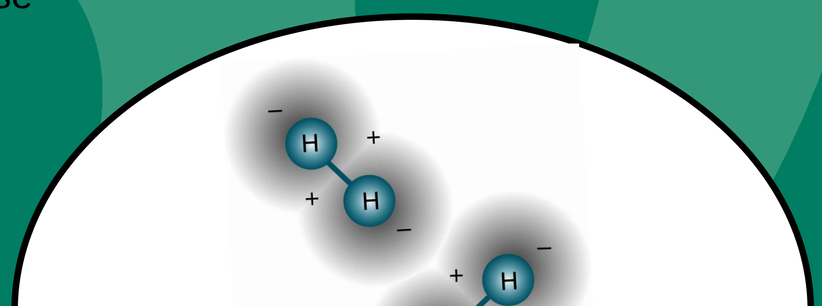
Lab experiment

The evaluation of the biological methanation process is further assessed with the above proposed experiment.

In addition to the daily feedstock, the necessary quantities of hydrogen are injected into a modified 5-litre lab scale reactor. A gas pump recirculates the produced biogas and hydrogen mixture to enhance contact phase and retention time for the Sabatier reaction. The carbon dioxide is thereby upgraded to biomethane as described in the Sabatier equation.

$4\ H_2 + CO_2 \rightarrow CH_4 + 2\ H_2O$

The final success of the upgrading process is determined by a gas chromatograph. A PLC provides the control of the experiment to adjust the injection of hydrogen and gas recirculation. As a consequence the methane production almost doubles and carbon dioxide is successfully removed.



Life cycle assessment

The results of the experiment are compared to a duplicate reactor without hydrogen injection. The gained data are further subjected to life cycle assessment including detailed carbon and energy balances. In addition, performance indicators of the biological methanation process will reveal the efficiency of this upgrading system.

Outlook

In a next step, the experiment will be gradually extended and will combine 2-phase food waste digestion and biological methanation at lab scale. This will be carried out by injecting the hydrolysis gas and external hydrogen into the methane reactor of the 2-phase system.

In a future outlook this data will be implemented in a model of a full scale biogas plant. In this scenario, the storage capability of biogas with the associated external hydrogen functions as a "battery" of the electricity grid.

Summary

- Assess the biological methanation process in lab scale
- Interrogate innovative biogas systems such as multi-phase digestion and use of hydrogen to upgrade biogas
- Evaluate sustainability and cost-benefit of innovative biogas systems