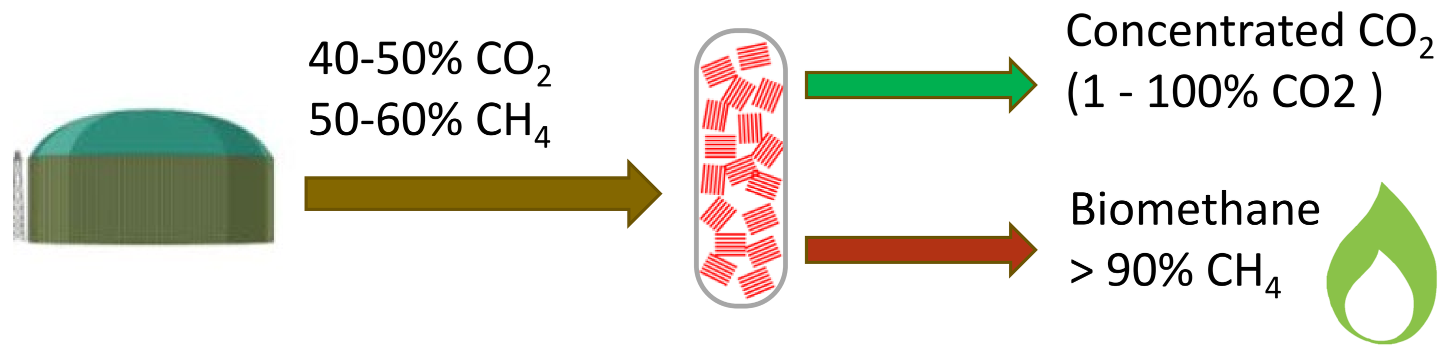
CO2 FROM BIOGAS USING IER SORBENT AND AIR PURGE

Wim Brilman, Michel Schellevis, Abhinav Srinivas

University of Twente, Fac. Science and Technology, PO Box 7500 AE Enschede, The Netherlands *contact: d.w.f.brilman@utwente.nl*

INTRODUCTION



Above 1% CO_2 in air (vs. 400 ppm) is typical sufficiently concentrated for microalgae cultivation

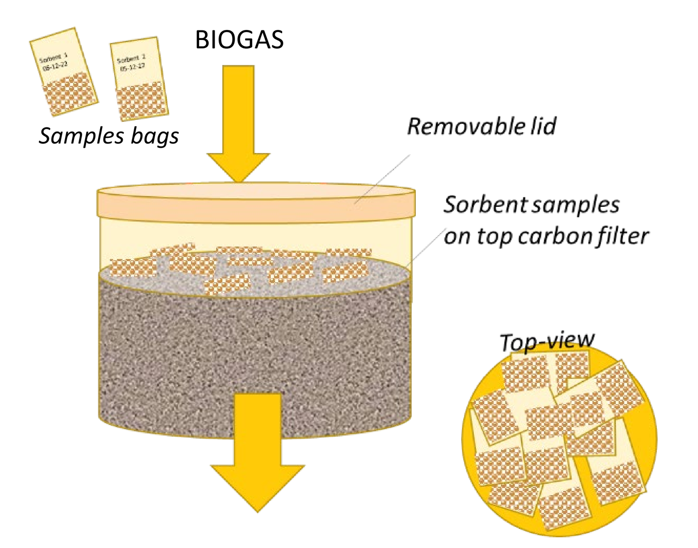
Separating biogas into a concentrated CO_2 stream for microalgae cultivation and biomethane (for bio-LNG, local methane gas grid or CHP) on small scale (say, 10-100 Nm^3/h) requires a cost effective and robust separation technology.

SUPPORTED AMINE - ION EXCHANGE RESIN AS CO2 SORBENT

- In the IDEA project, CO2 was successfully captured from ambient air using a a polymeric supported amine IER sorbent. The same selective sorbent is used here
- Sorbent is relatively expensive and some degradation was observed in above study. Hence, sorbent stability will be studie for biogas separation conditions
- The IER sorbent binds CO2 relatively fast and strong. Sorbent regeneration can be done by temperature increase or CO2 partial pressure decrease.
- The low thermal conductivity of the sorbent makes rapid cycling *with temperature swing regeneration* not feasible.
- Considering P_{CO2} in biogas = 45% and P_{CO2} in air = 0.042%, a novel concentration swing process, using air as stripping gas, was tested experimentally.

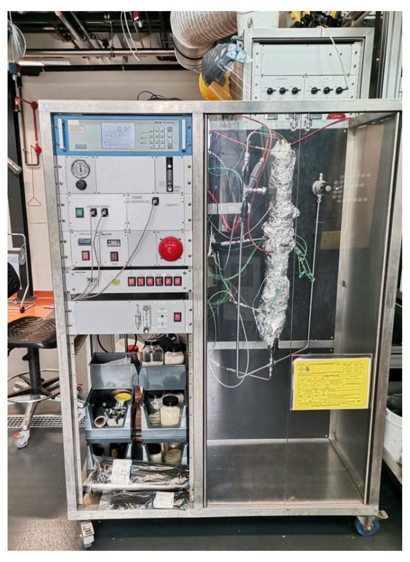
SORBENT STABILITY

Sorbent was exposed to real biogas at Heirbaut farm



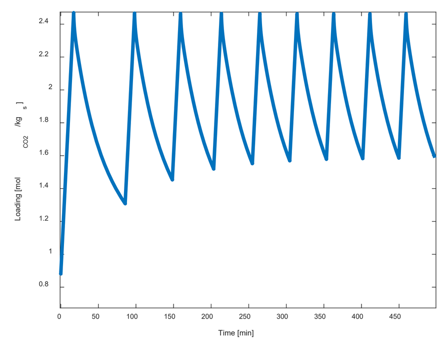
NO SIGN OF CO2 CAPACITY DECREASE WAS FOUND !

EXPERIMENTAL TEST OF CONCEPT

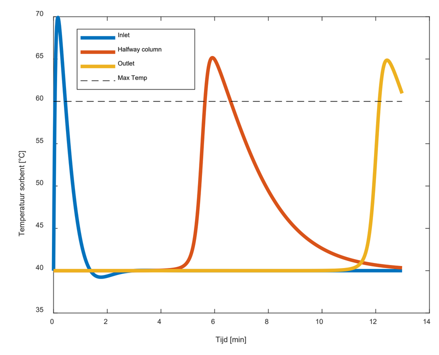


FIXED BED UNIT

- Adiabatic concentration swing
- Using air stripping of CO_2 for sorbent regeneration
- Higher operating temperature leads to lower T-excursion, but also lower cyclic capacity



Development of a cyclic steady state. Trade-off between cyclic capacity and maximum T in bed.

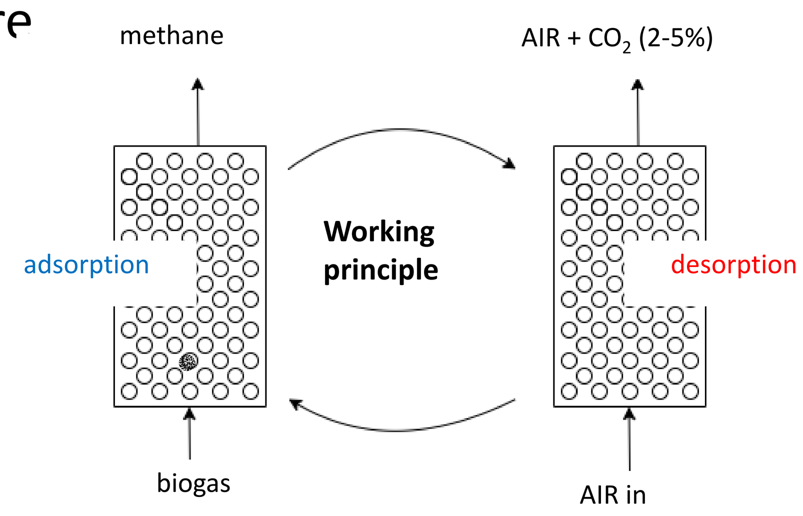


During adsorption a temperature front moves through bed. Re-use of ΔH_{Ads} is key

PROCESS DESIGN

Concept:

- Co-current concentration swing separation
- no heating/cooling (re-use heat of adsorption)
- ambient pressure

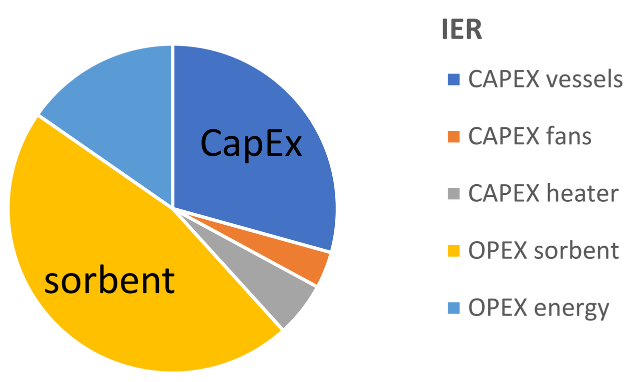


TARGETS: purity: CH_4 > 90%; CO_2: > 1%
recovery: CH_4 > 99.5 %; CO_2: (high)
maximum temperature < 70 °C
productivity: as high as possible

DESIGN - OPTIMIZATION

- Inlet Temperature (ADS+DES): 40°C
  Pressures (atmospheric)
- Gas velocity (DES/ADS) = 2:1
- Cyclic capacity: 0.58 mol CO_2/kg
- CH_4 purity 93 % & CH_4 recovery 99.7%
- CO_2 purity 2.4 % (in air) CO_2 recovery 99.3%
- Productivity: 47 Nm^3/h per m^3 sorbent
- Power consumption: 0.10 kWh/Nm^3
- Estimated costs: 0.11 €/Nm^3 biogas

CONCLUSIONS



Principle is shown in lab unit
Model can describe experiments
Conceptual design is made

Next steps required: evaluation of business case. Alternative sorbent ?

IDEA - Implementation and development of economic viable algae-based value chains (NWE639)

Duration: 9/2017 – 10/2021, capitalisation till 12/2023

Website: www.nweurope.eu/IDEA

Lead partner: VITO, Belgium

Full IDEA partners: