Anaerobic digestion of urban bio-waste and utilization of digestate as a nutrients source for biogas upgrading

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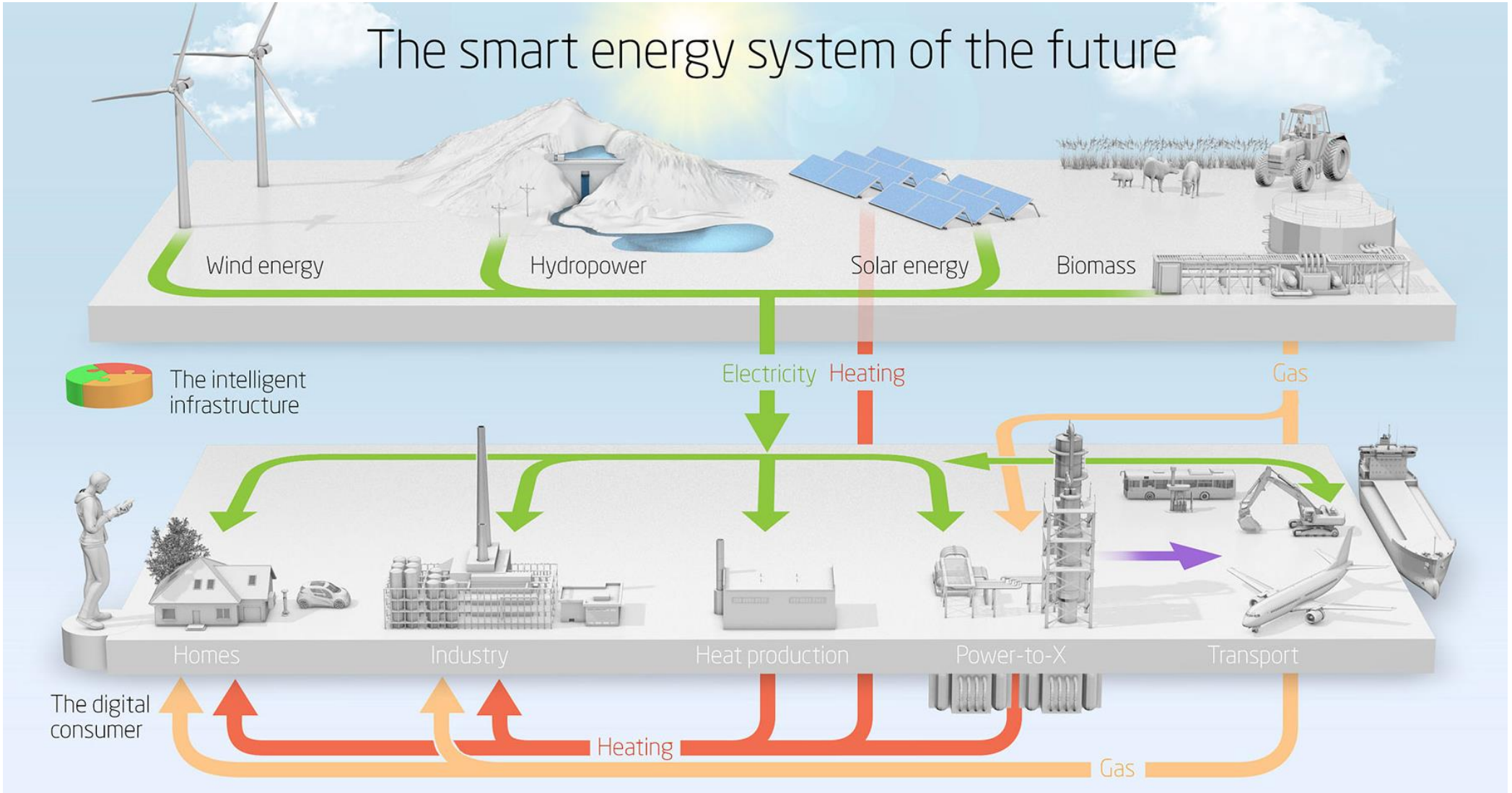
Power-to-X and role of gas



https://www.dtu.dk/english/news/nyhed?id=%7BAC41C8C0-13CF-4568-A247-58996DF8D0D8%7D

Excess electricity

Ørsted to pilot green H2 in Denmark with Siemens Gamesa offshore turbines

Demonstration project H2RES

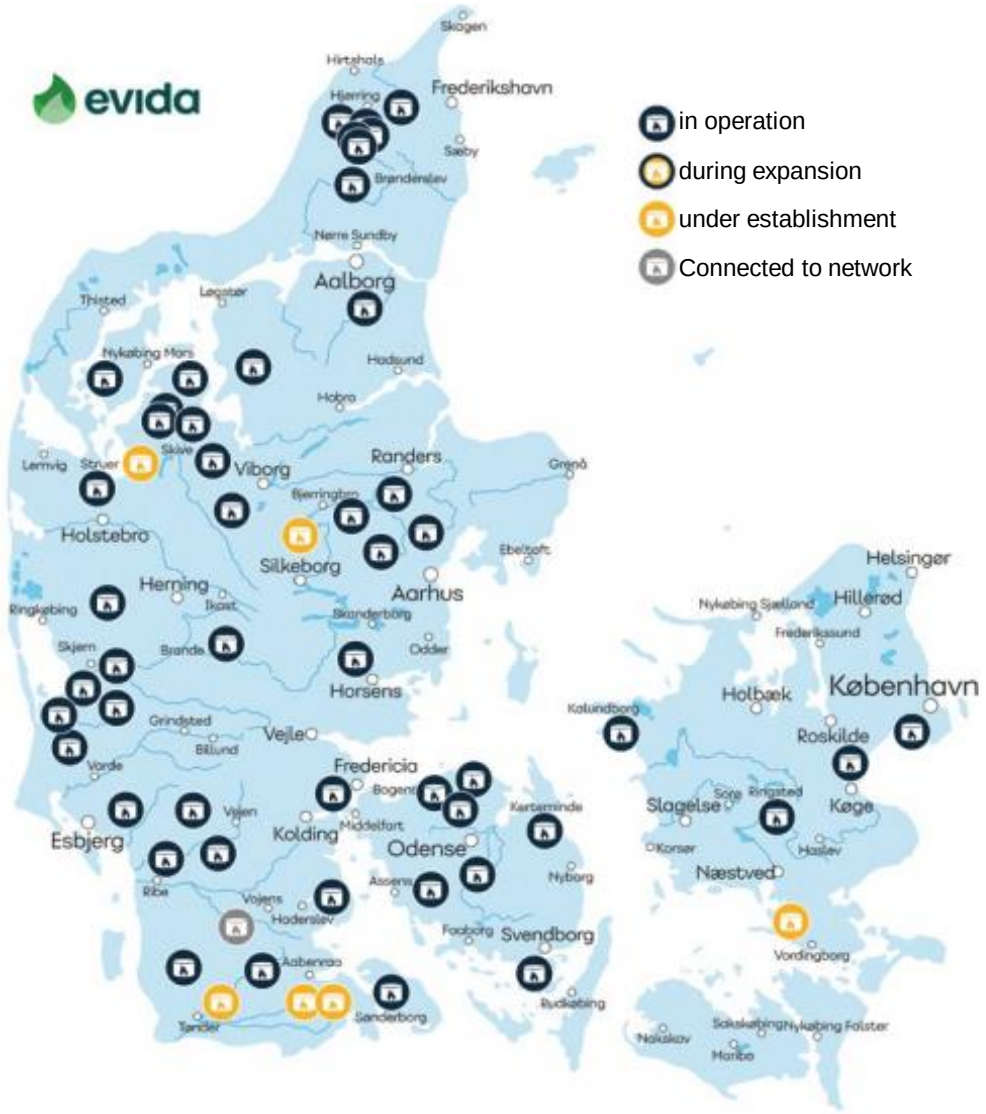
Orsted plans 'world first' 5GW offshore wind energy island

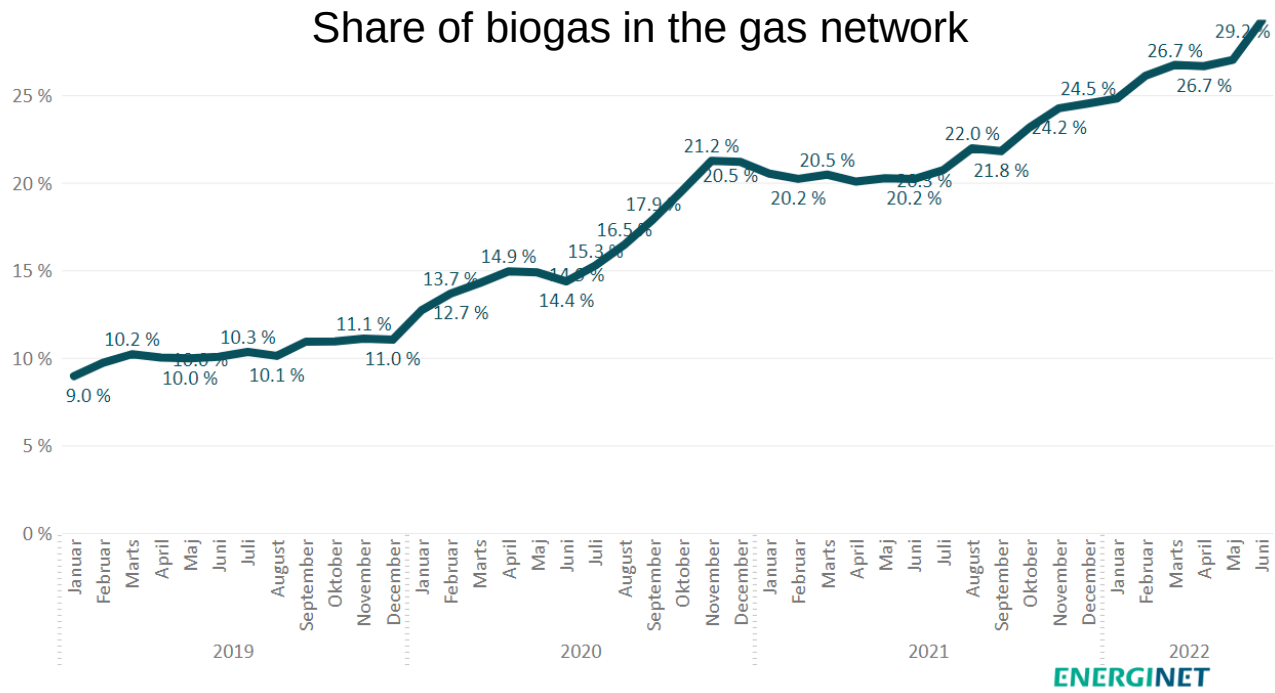
Hub based on Baltic island of Bornholm could link Denmark with Poland, Germany and Sweden and produce green hydrogen

Glimpse of the future: Danes unveil vision of world's first artificial energy island

Group of pension funds and utility Andel reveal animation showing North Sea island linked to offshore wind

Biogas in Denmark

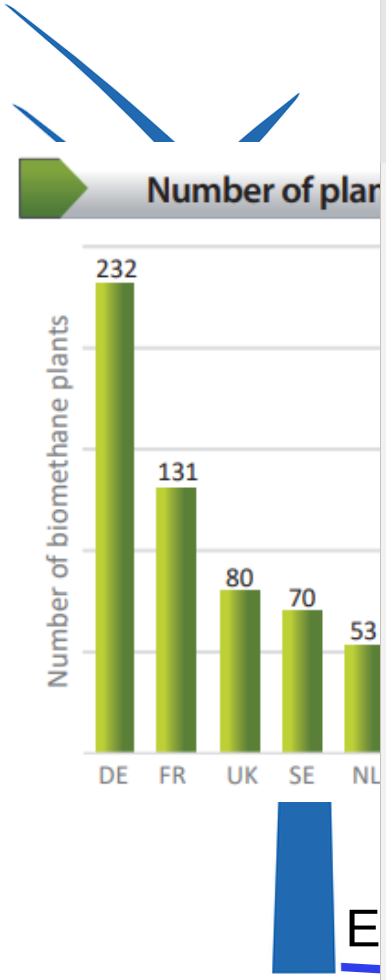


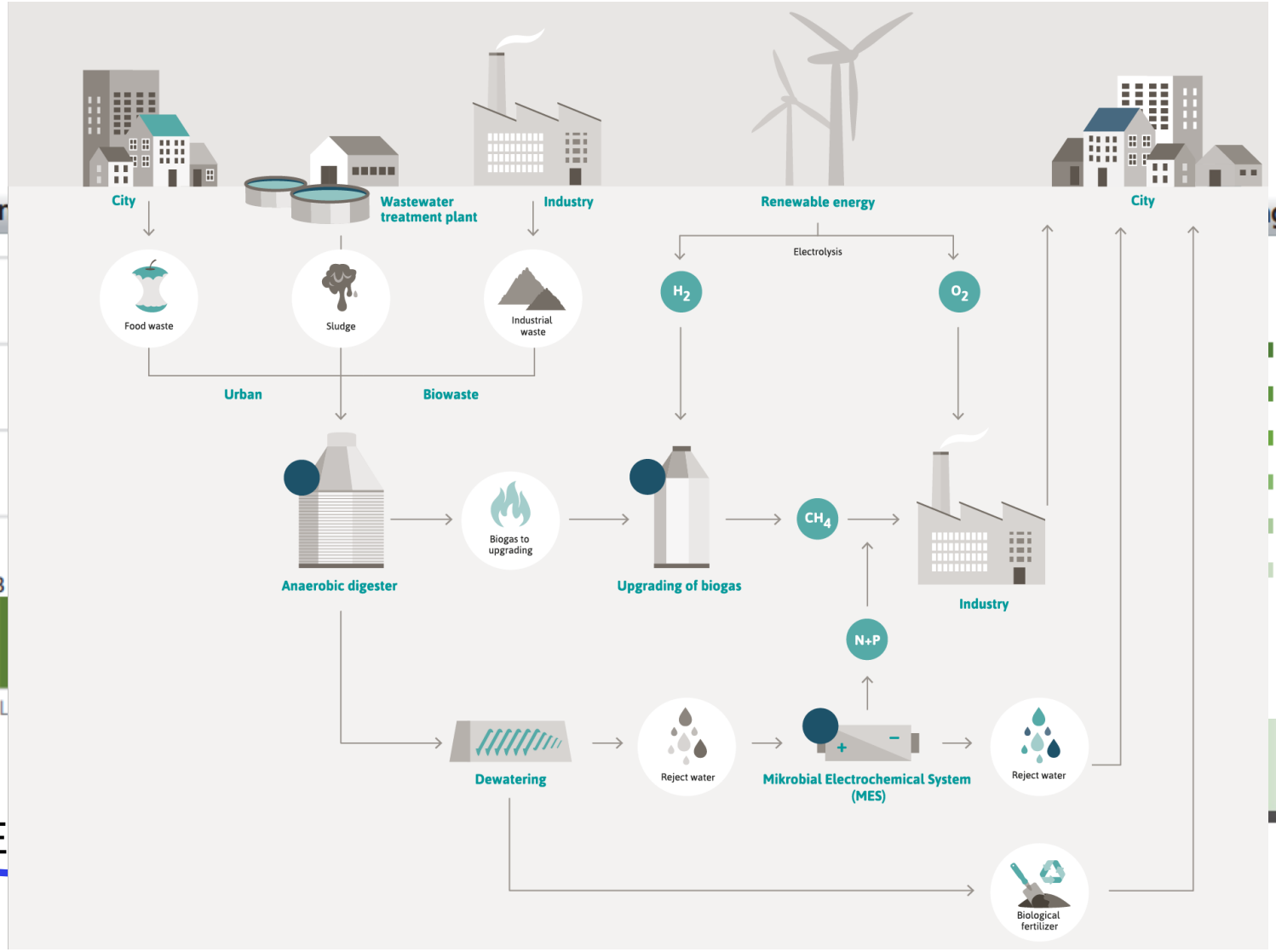


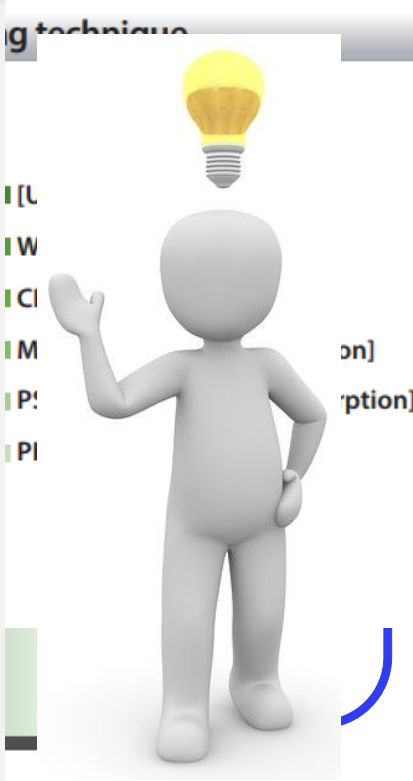
- Most biomethane per capita upgraded to the gas system
- 2nd in absolute numbers in EU after Germany
- Aim to have 40% biomethane by 2025

https://energinet.dk/

Biomethanation and circular economy







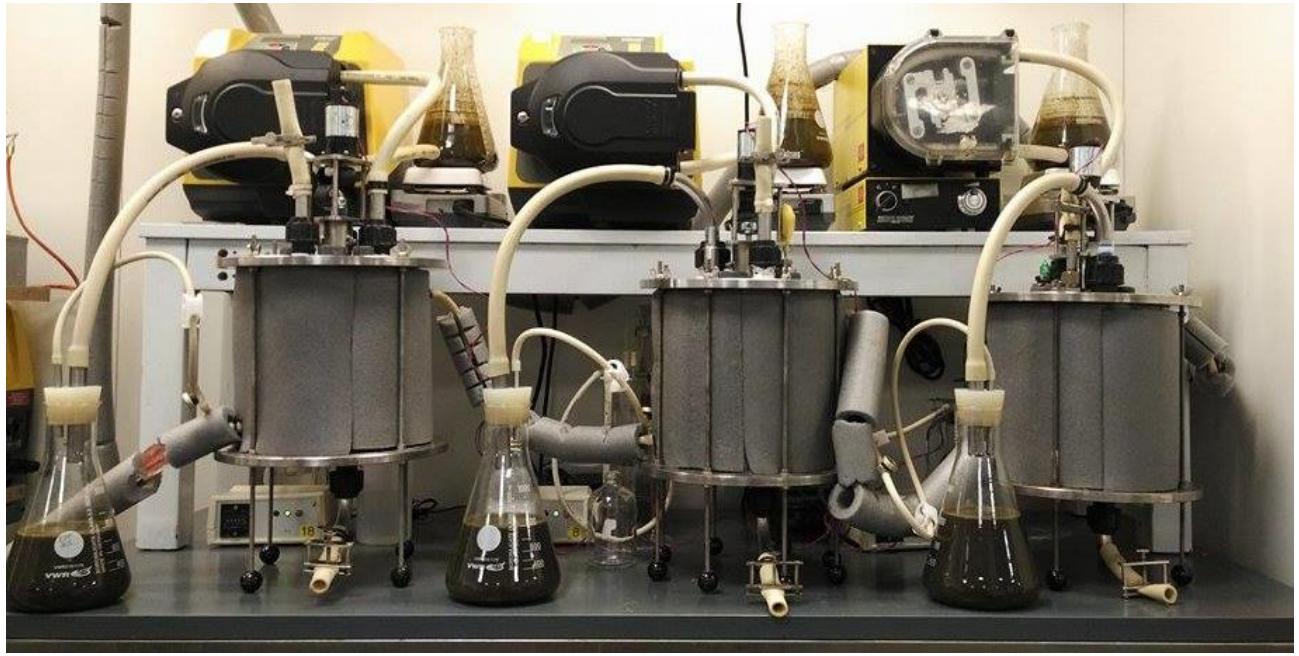
Project VARGA (Water Resource Recovery Facility)

Objectives

- Improve biogas productivity using urban biowaste
- Explore digested biowaste as nutrient source for biomethanation
- Explore changes on microbial communities
- Validate process efficiency at up-scaled operation

Infrastructure

Lab scale operation

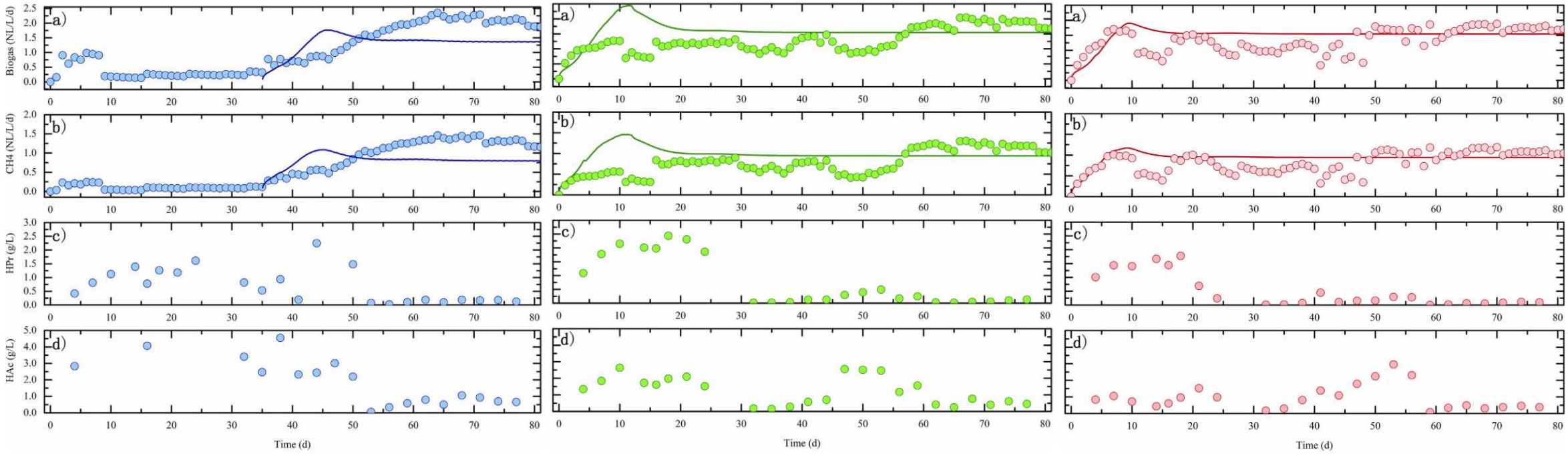


Inoculum (v/v): 10% 50% 100%

Pilot scale operation

Lab scale: Start-up operation

Inoculation volume (v/v): **10%** **50%** **100%**



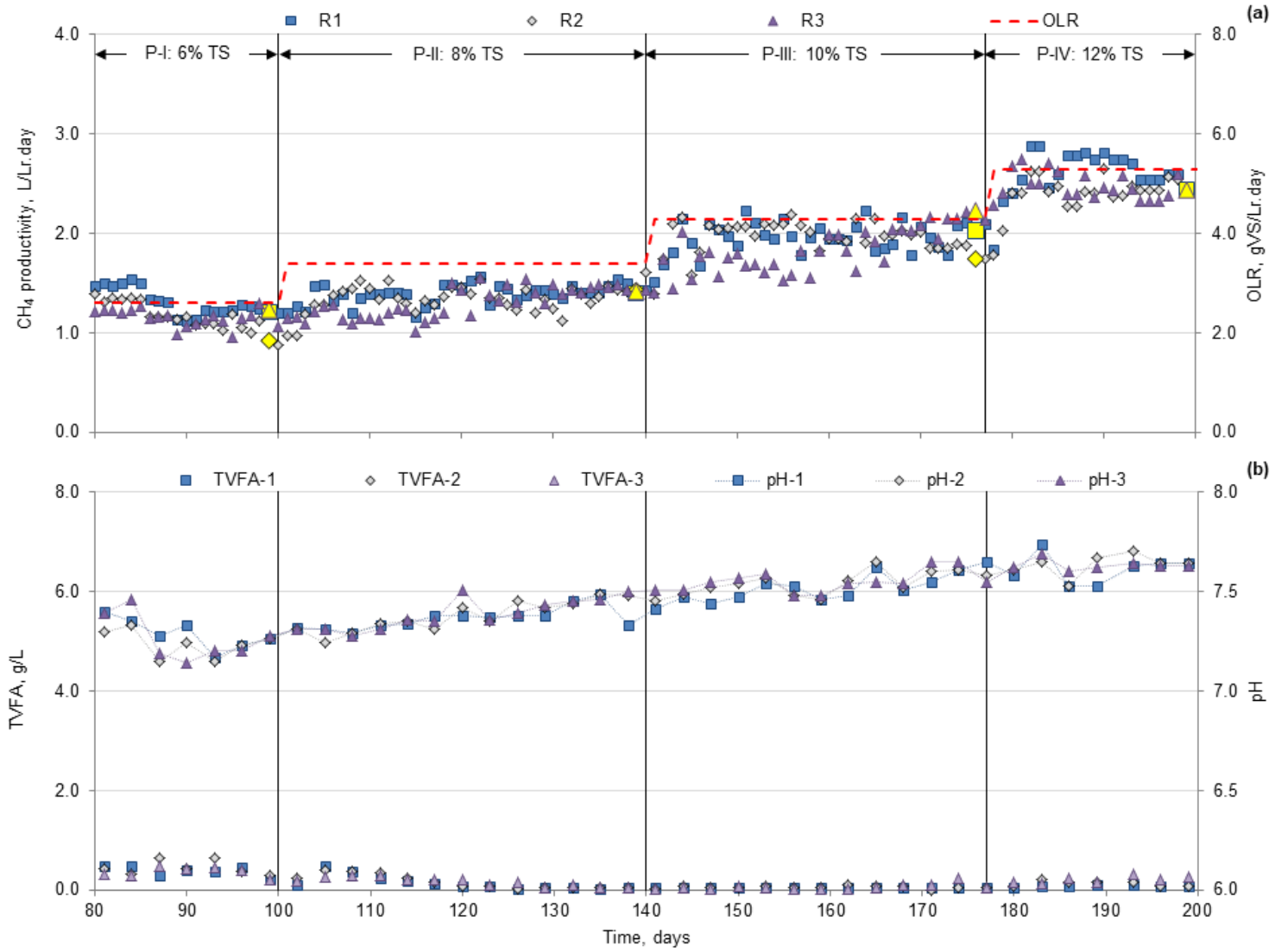
Highlights

- Low inoculation volume: lag phase increase and acidification incidents
- Steady-state: similar process efficiency

Lab scale: Long-term operation

Highlights

- Similar performance of triplicates
- Stable production
- Steady increase of CH_4 productivity
- No pH drops
- No VFA accumulation



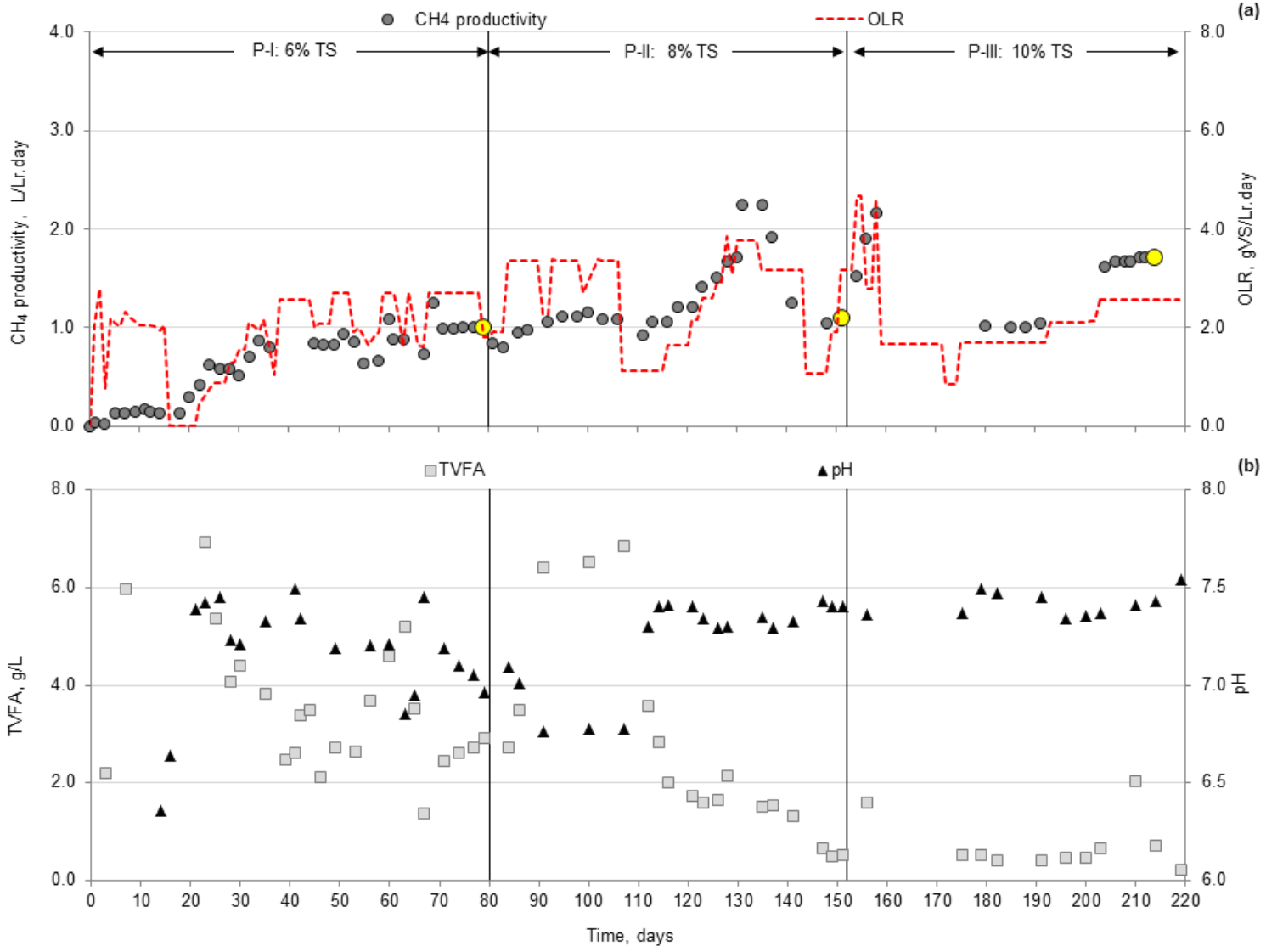
Pilot scale anaerobic digestion

Operational challenges

- Temperature fluctuations (0-15 d)
- Mixing malfunctioning (110-150 d)
- Alternating feeding (whole duration)

Highlights

- Lag phase <20 d
- VFA accumulation during lag phase
- Stable pH
- Similar efficiency with lab scale at steady-state



Overall microbial communities

In total

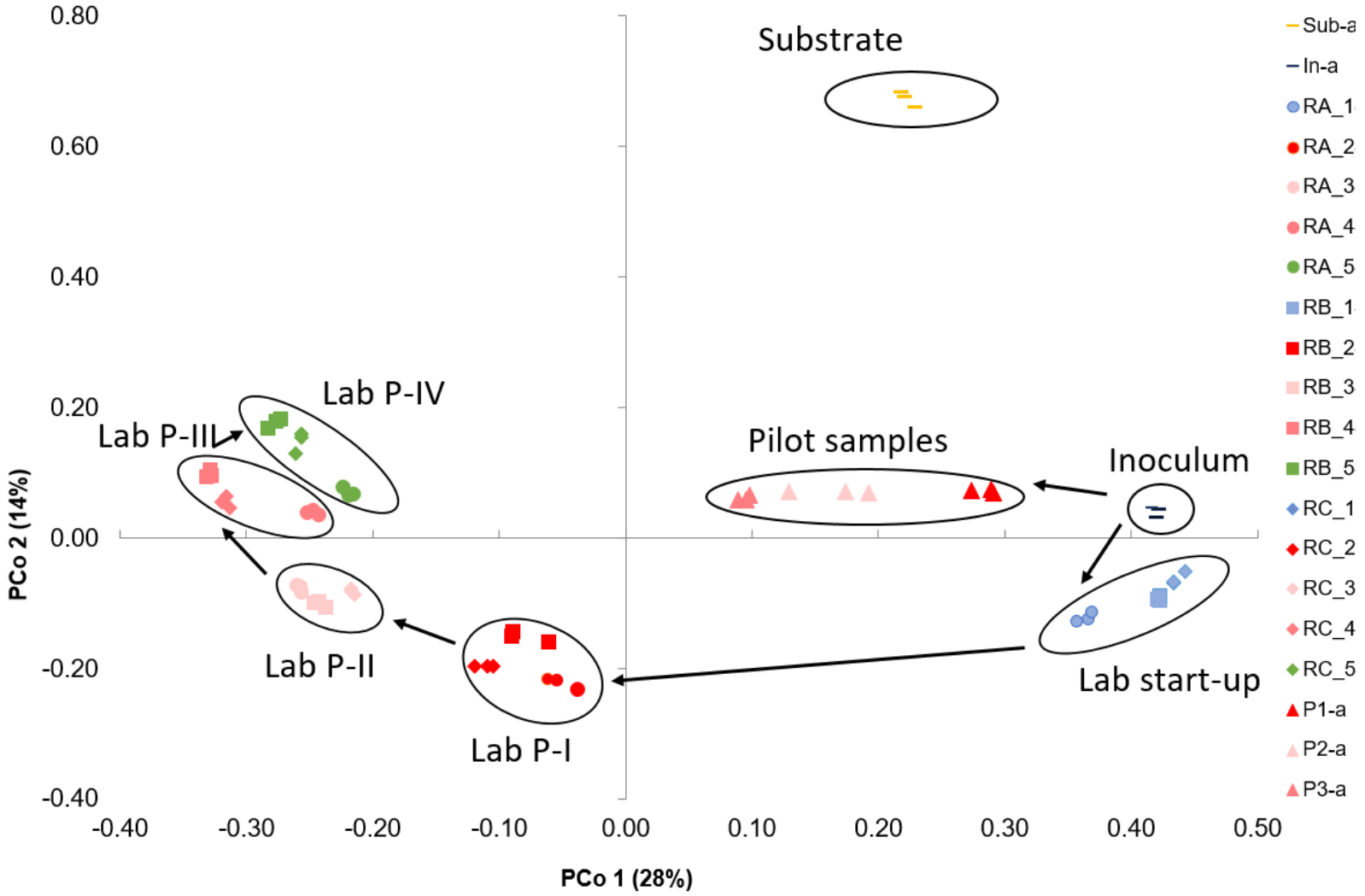
- 54 AD microbiomes
- 453 OTUs

Samples

- 3 lab CSTRs at 5 OLRs
- 1 Pilot at 3 OLRs.

Principal coordinate analysis

- *Substrate:* distinctly different
- *Lab-scale:* clustering together at the different phases
- *Pilot scale:* separate cluster



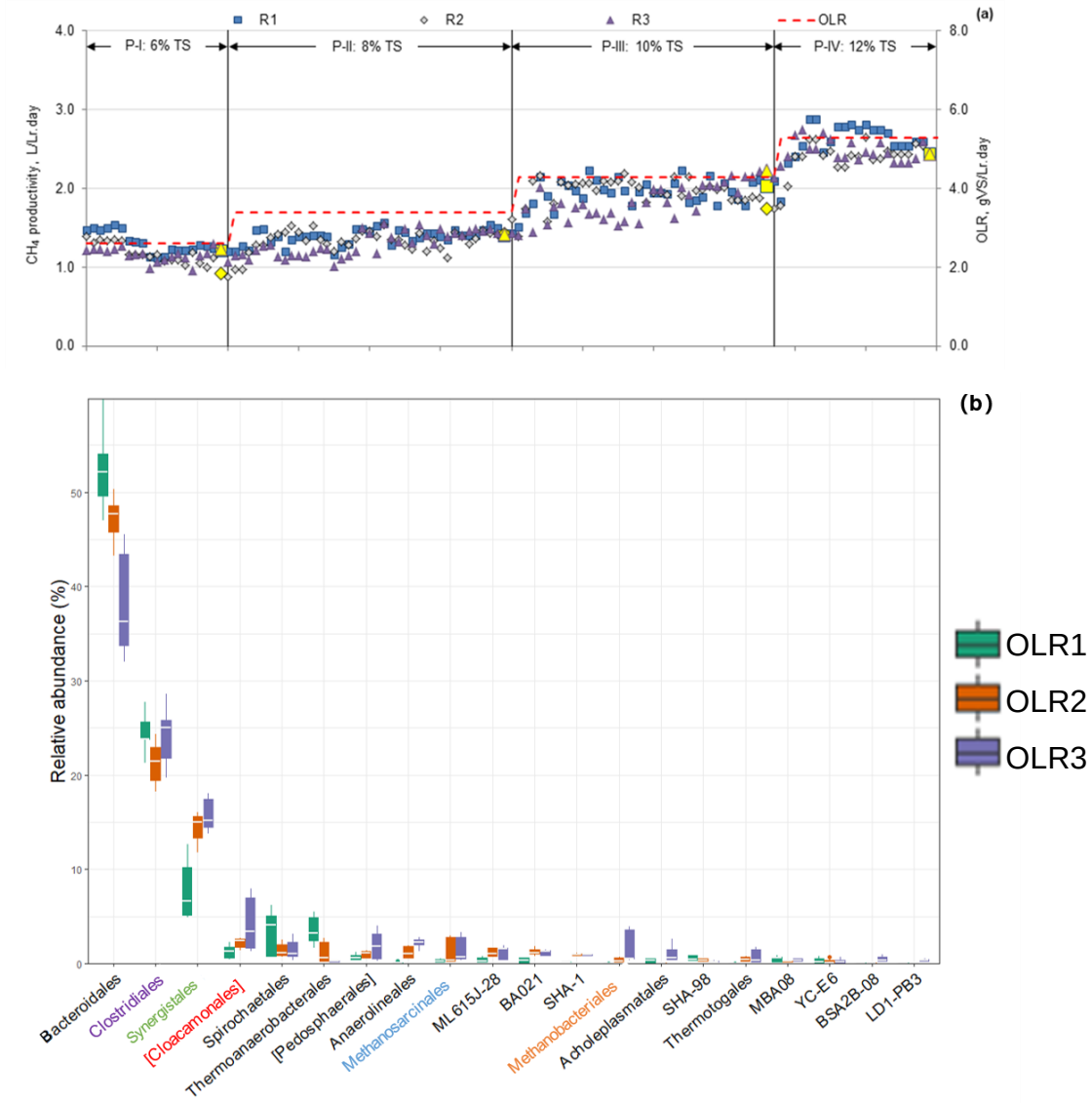
Lab-scale microbiome

AD Microbiome:

- Initially composed of *Clostridiales* and *Bacteroidales*
- *Syntophomans schinkii* -potential SAO -and *Methanobacterium* genera that grown in syntrophy
- Adaptation at the operational conditions

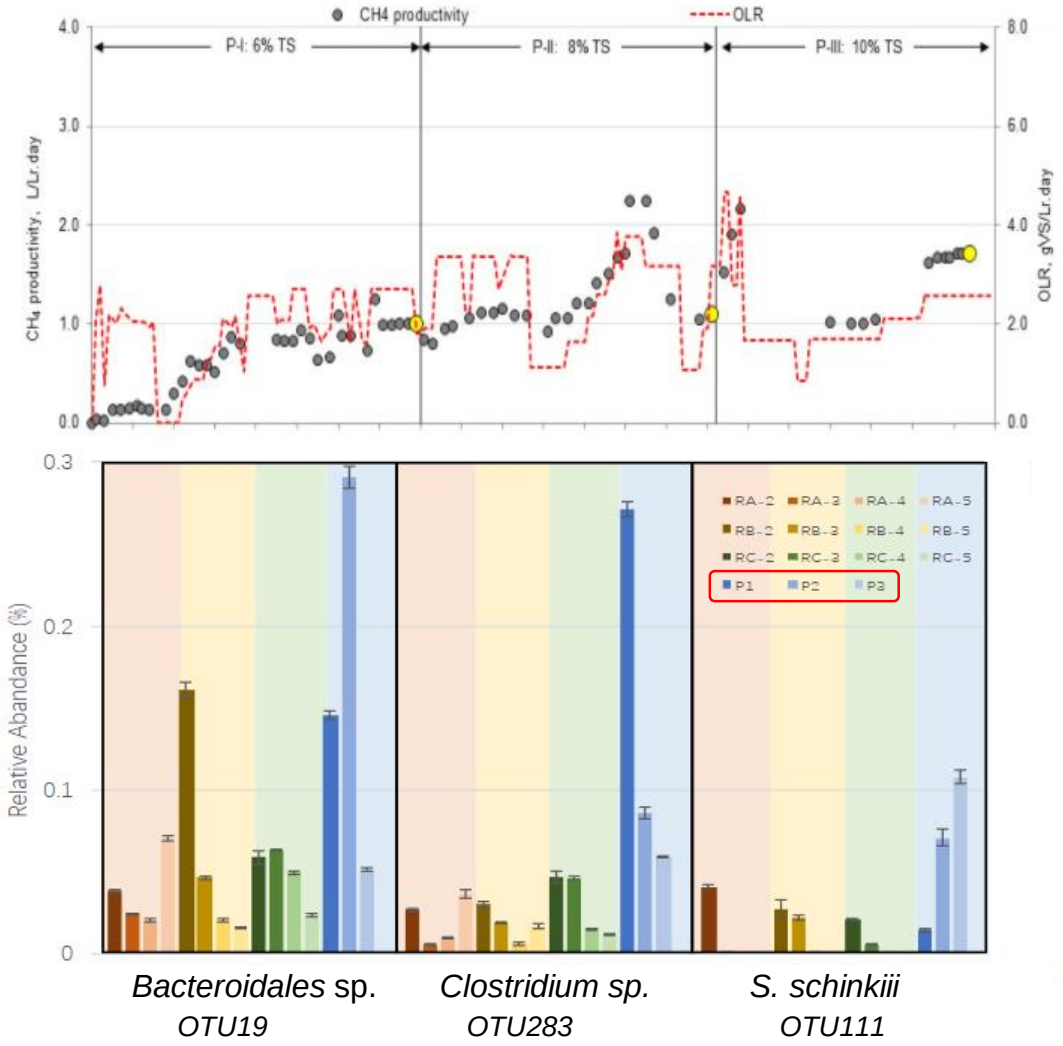
Increased OLR led to:

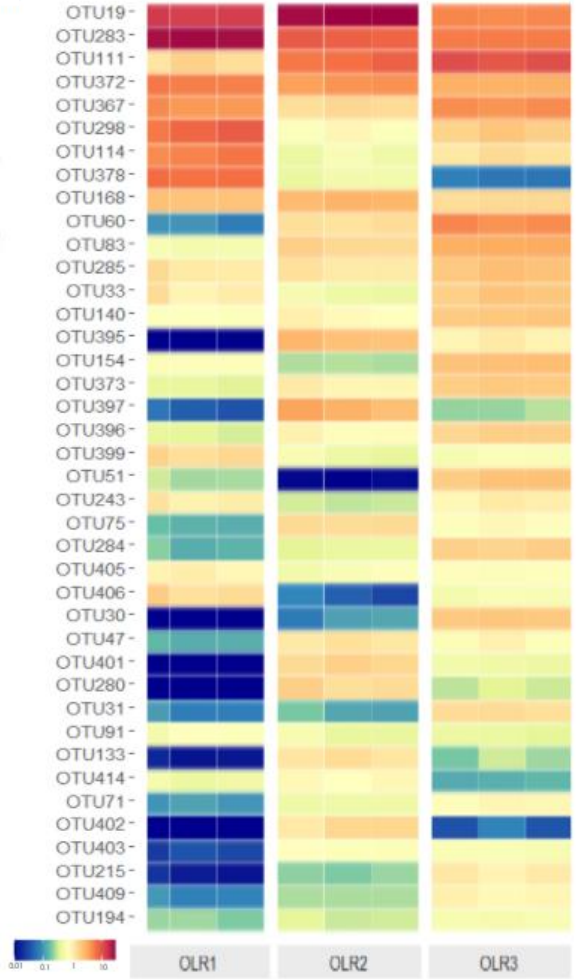
- Bacteria: Augmentation of *Synergistetes* members
- Archaea: *Methanosarcinales* and *Methanobacteriales*
- Overall: Transition to versatile acetoclastic/ hydrogenotrophic methanogenic pathway



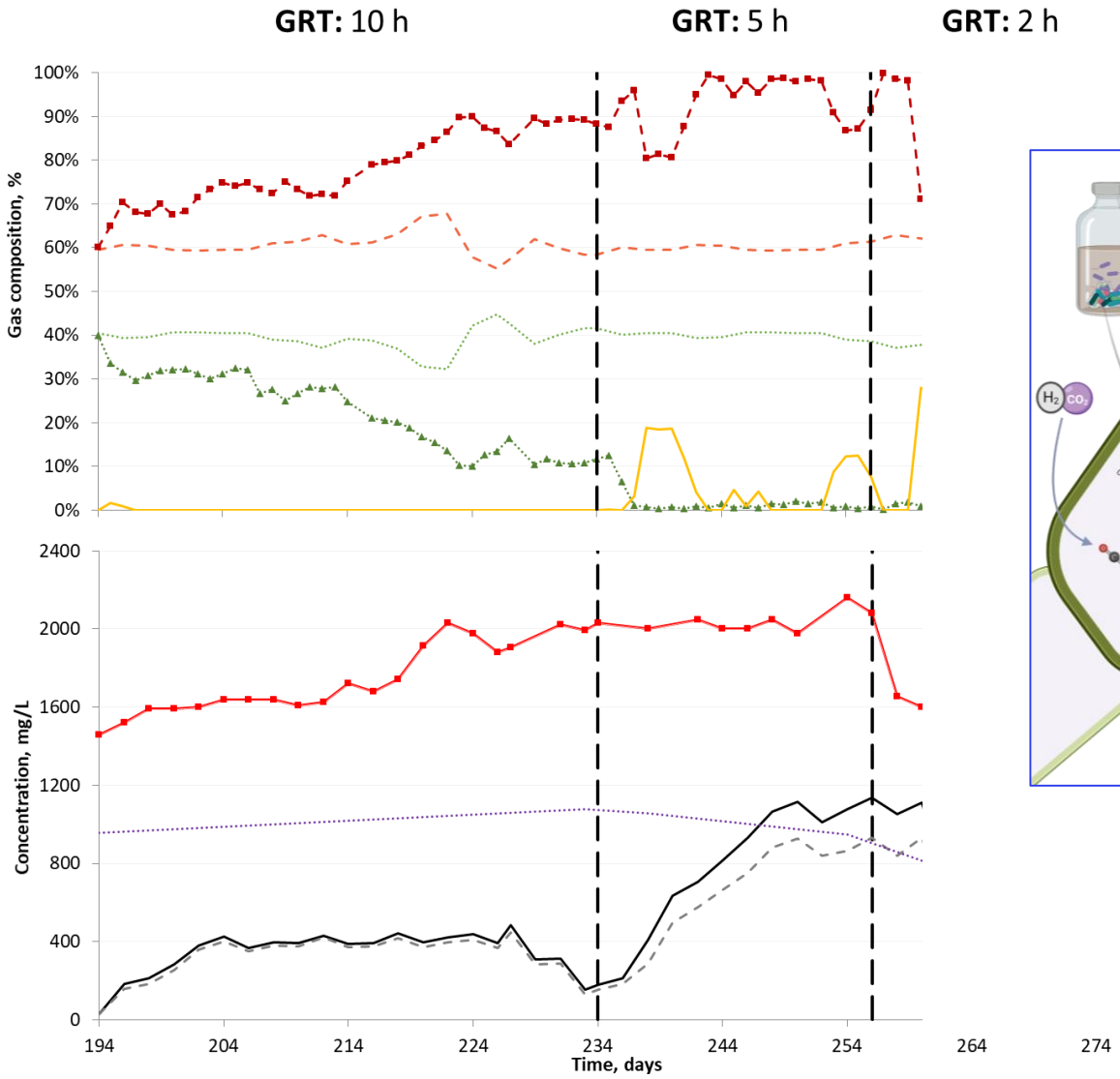
Pilot scale microbiome

- *Bacteroidales* was the most dominant order. Lab: ✔
- The predominance of these microbes was eliminated over operational time. Lab: ✔
- *S. schinkii* OTU111 dominated the microbial community at the end; Lab: ✘
- *Methanobacterium* spp. dominated the archaeal population at the end; Lab: ✔

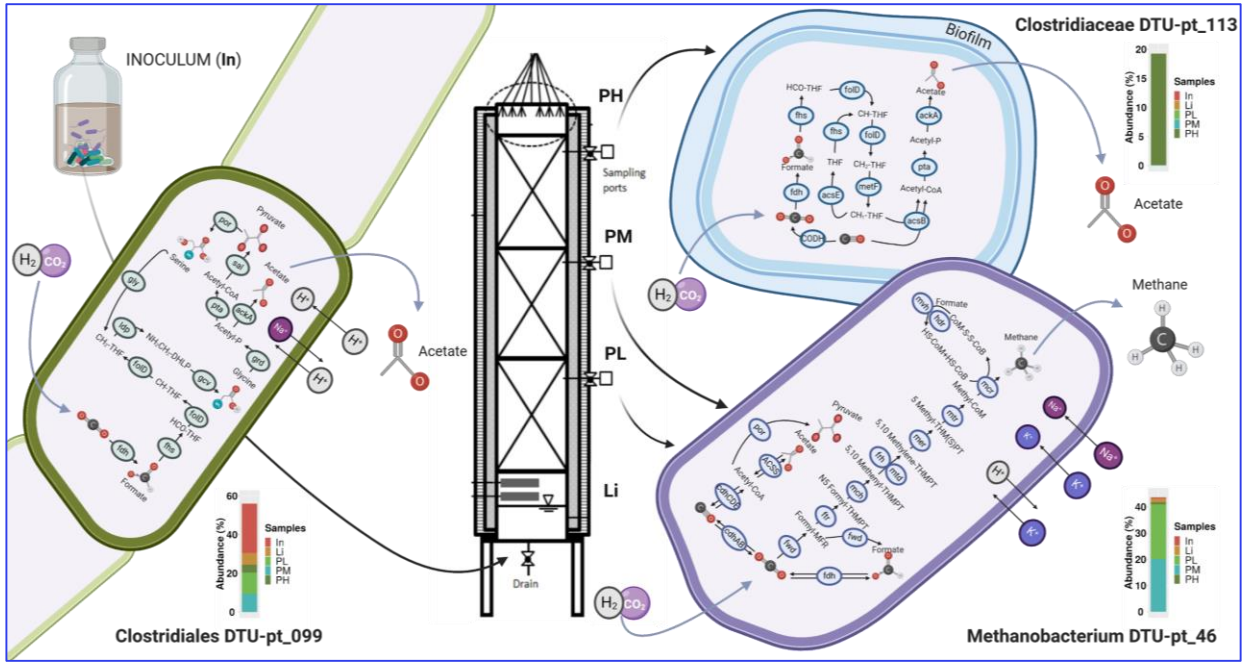




Pilot scale biomethanation



Microbial composition



Conclusions

Lab scale biogas production

- Stable performance at increased loading rates and long term operation
- Microbiomes at biological triplicates followed a similar pattern

Pilot scale biogas production

- Similar productivity with the lab-scale operation
- Robust microbiome was formed to alleviate process imbalances

Pilot scale biogas upgrading

- Digested biowaste can be used a suitable and cheap source of nutrients
- Production of biomethane complying with gas grid injection (>95% CH_4)

Thank you for your attention!!!

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