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SYNGAS BIOMETHANATION INTEGRATED WITH ANAEROBIC DIGESTION: EXPERIMENTAL ANALYSIS AND MODELING

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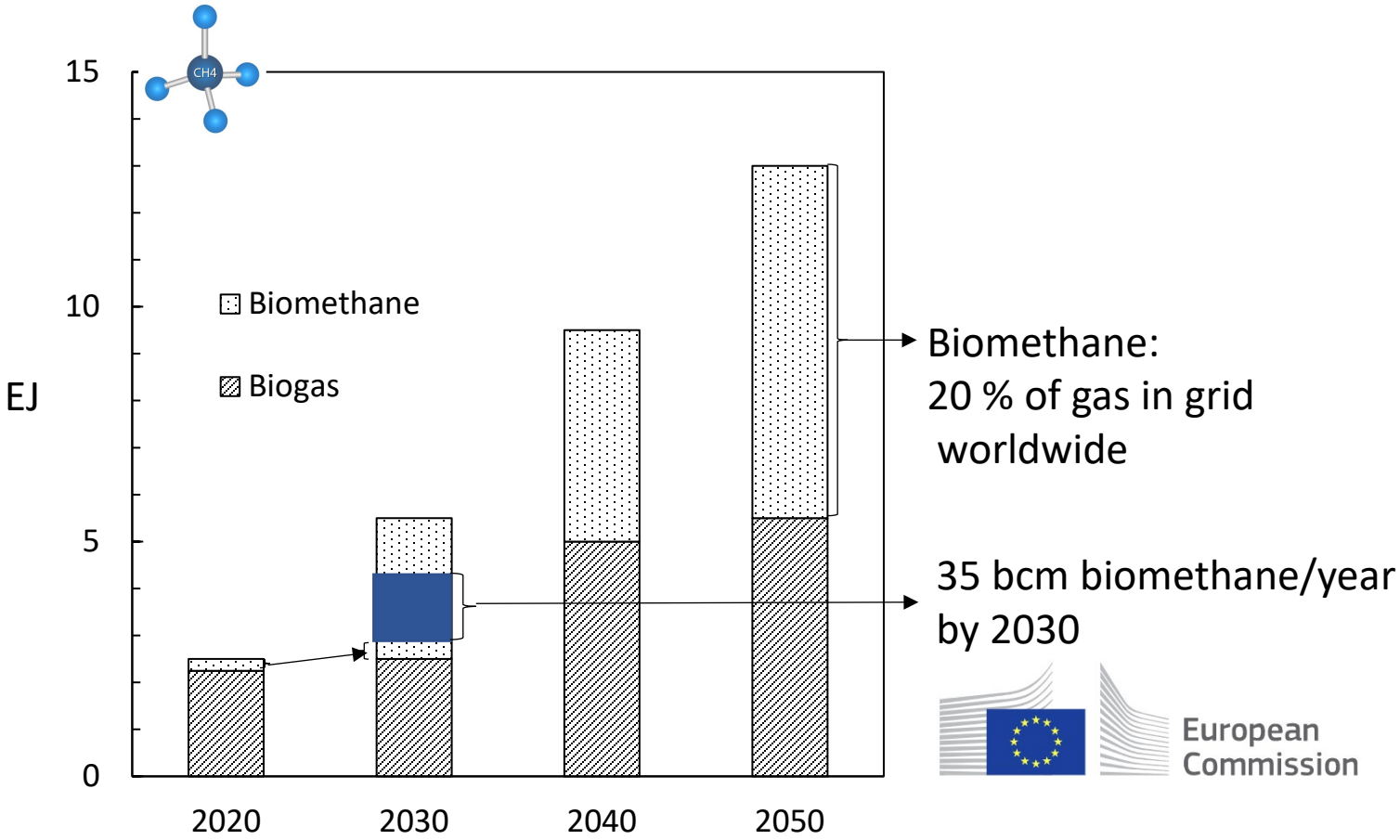
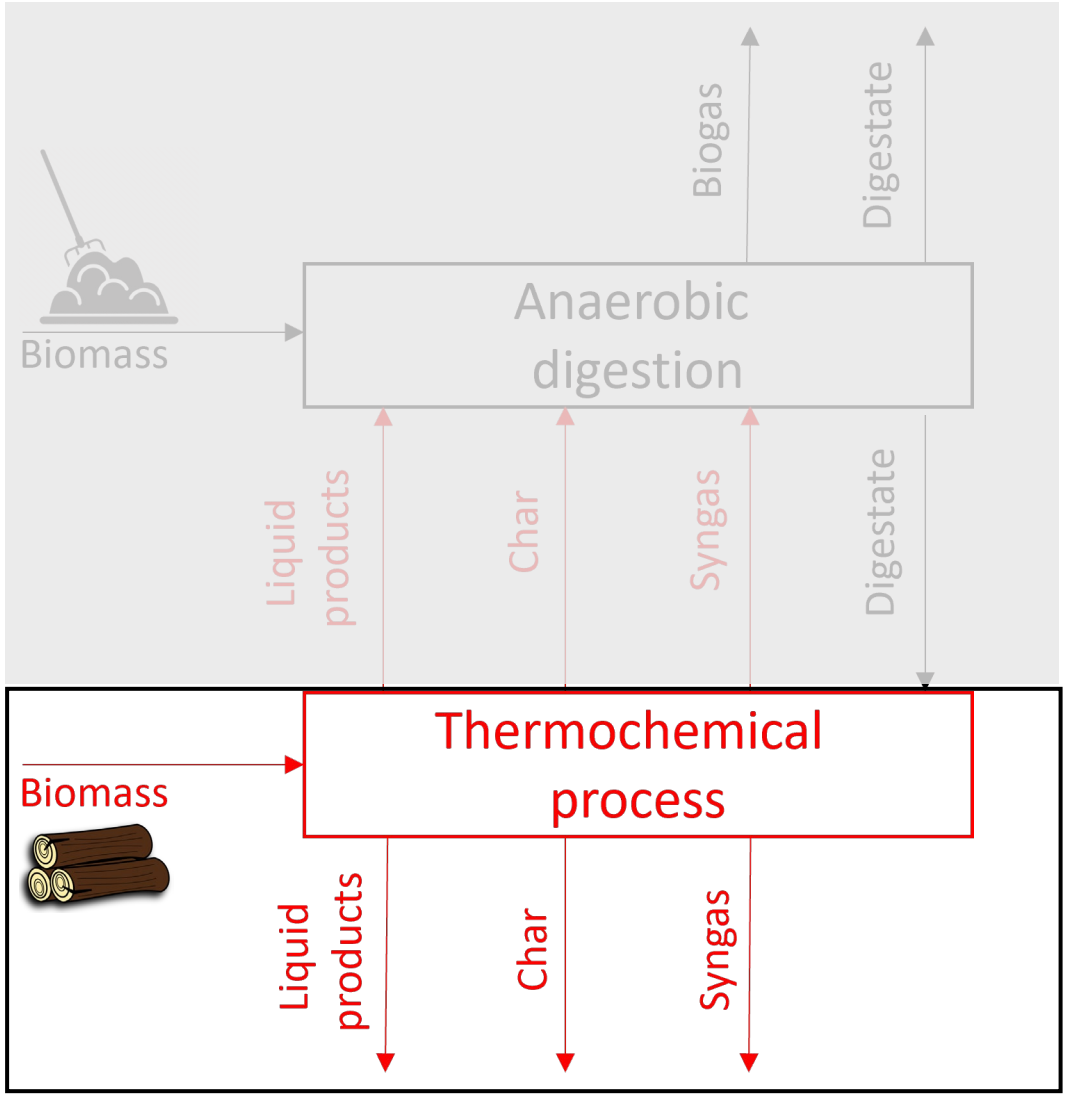


Biomethane:
20 % of gas in grid worldwide

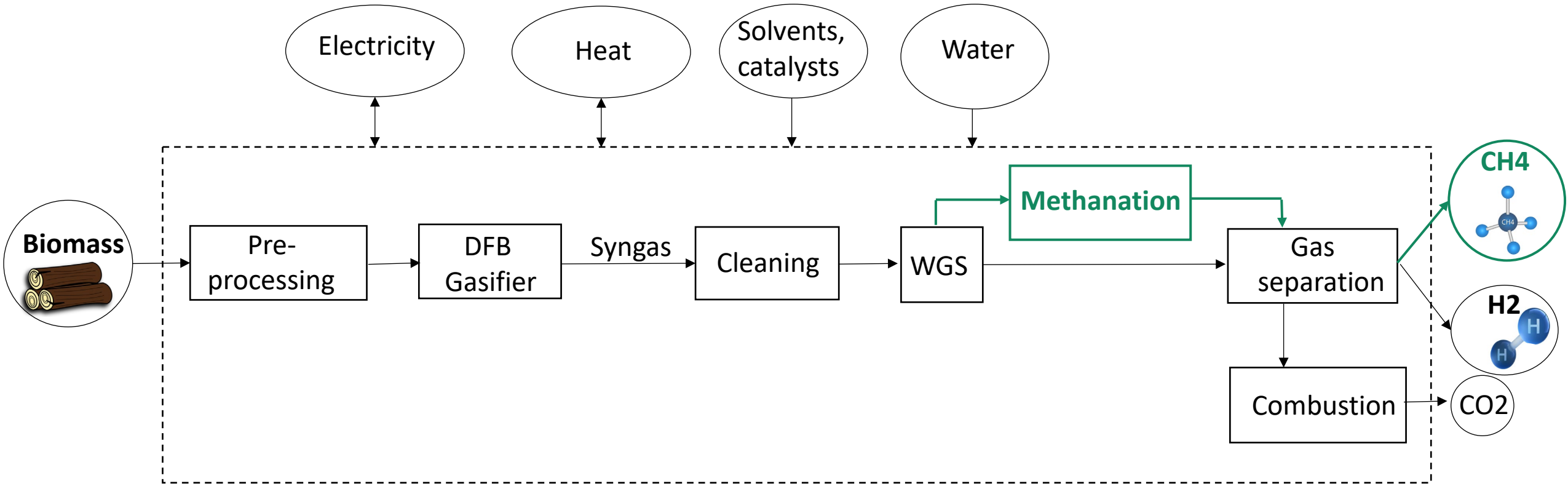
35 bcm biomethane/year by 2030

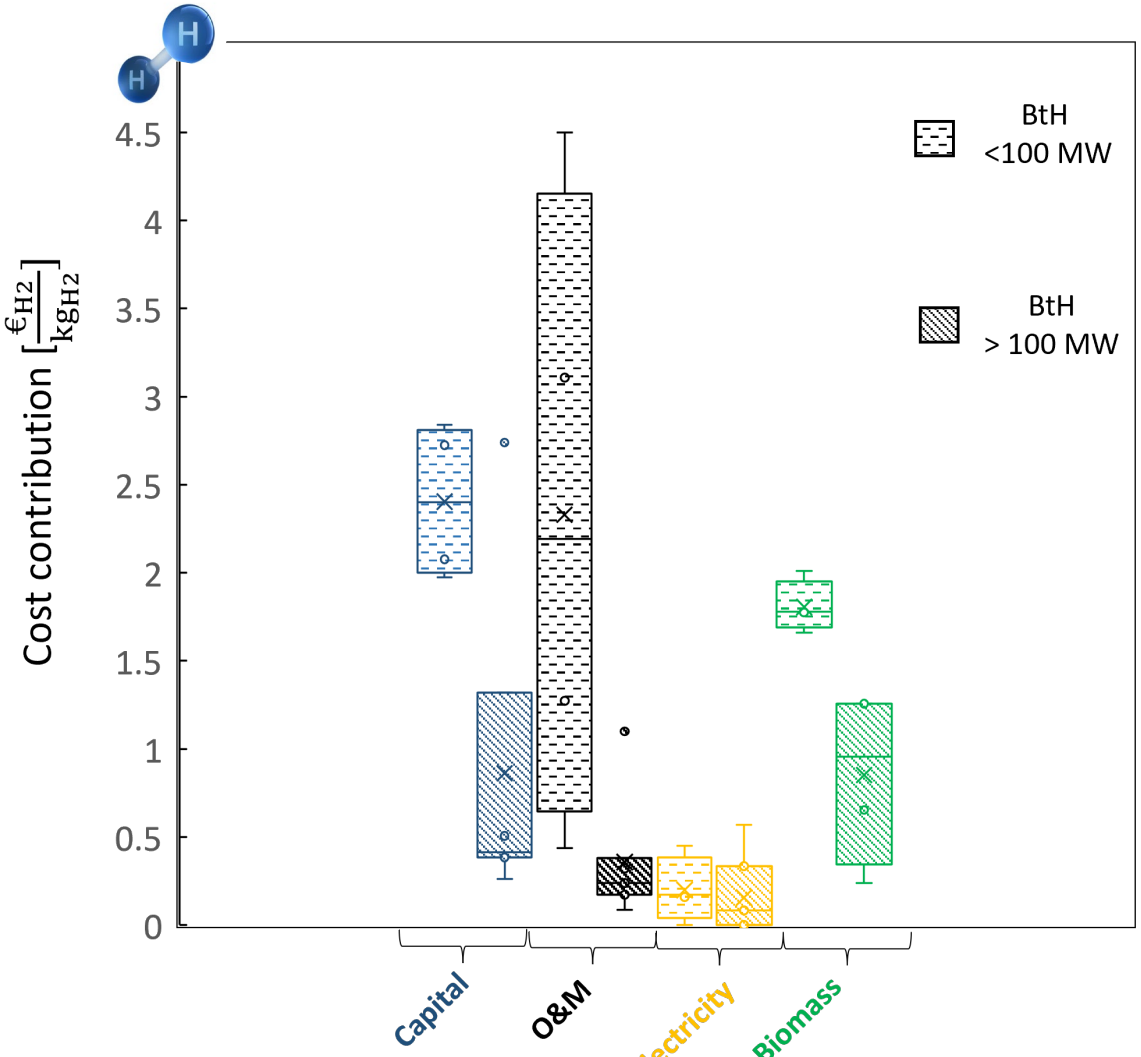
European Commission

[IEA, 2021]

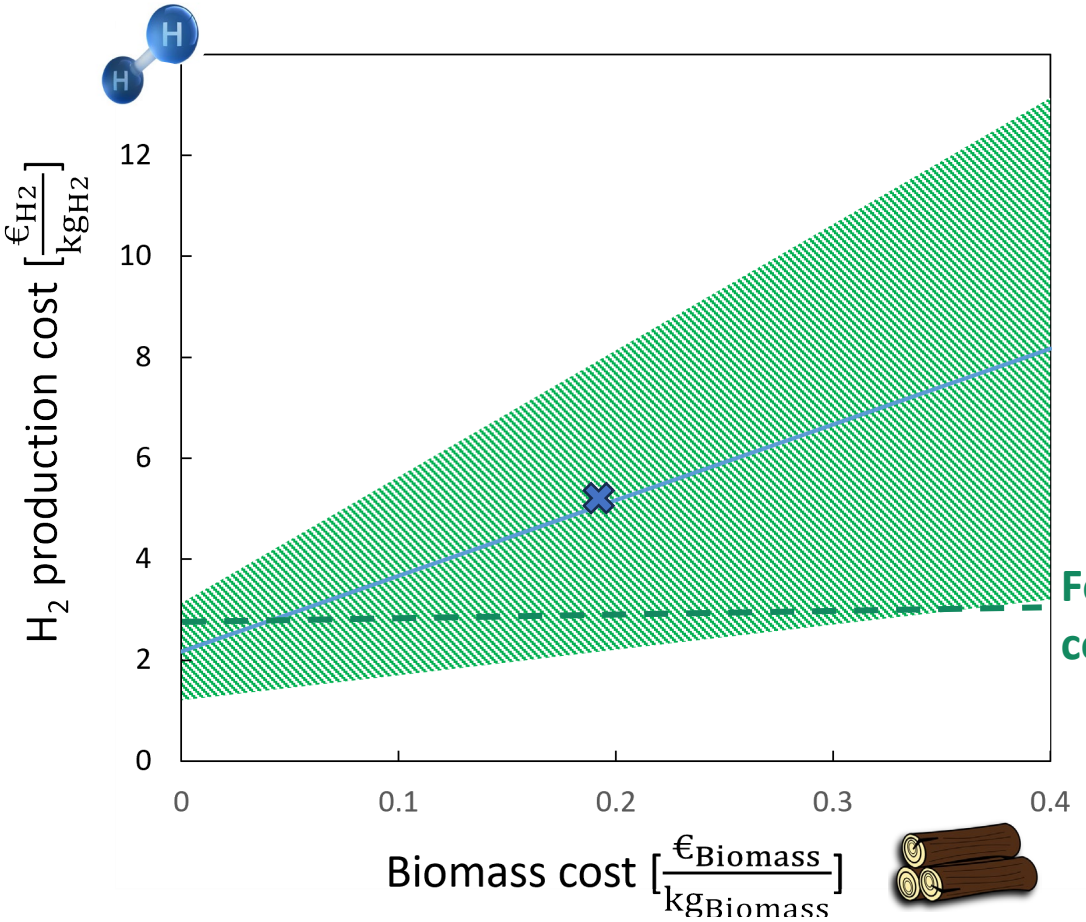

Biogas
Digestate
Biomass
Anaerobic digestion
Liquid products
Char
Syngas
Digestate
Thermochemical process
Biomass
Liquid products
Char
Syngas

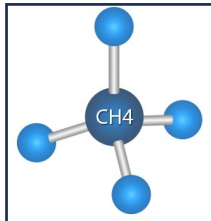
Biomass-to-hydrogen/methane generic flowsheet



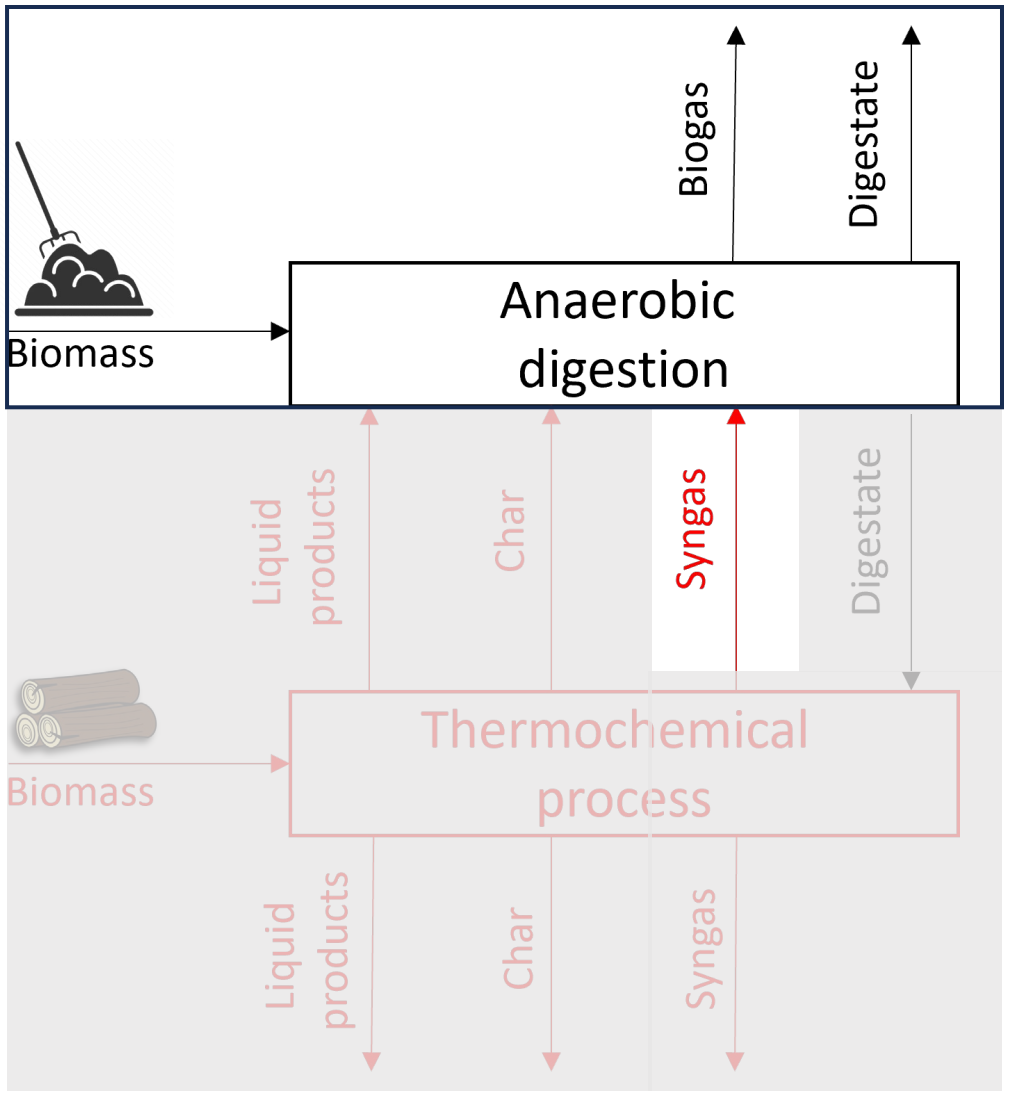


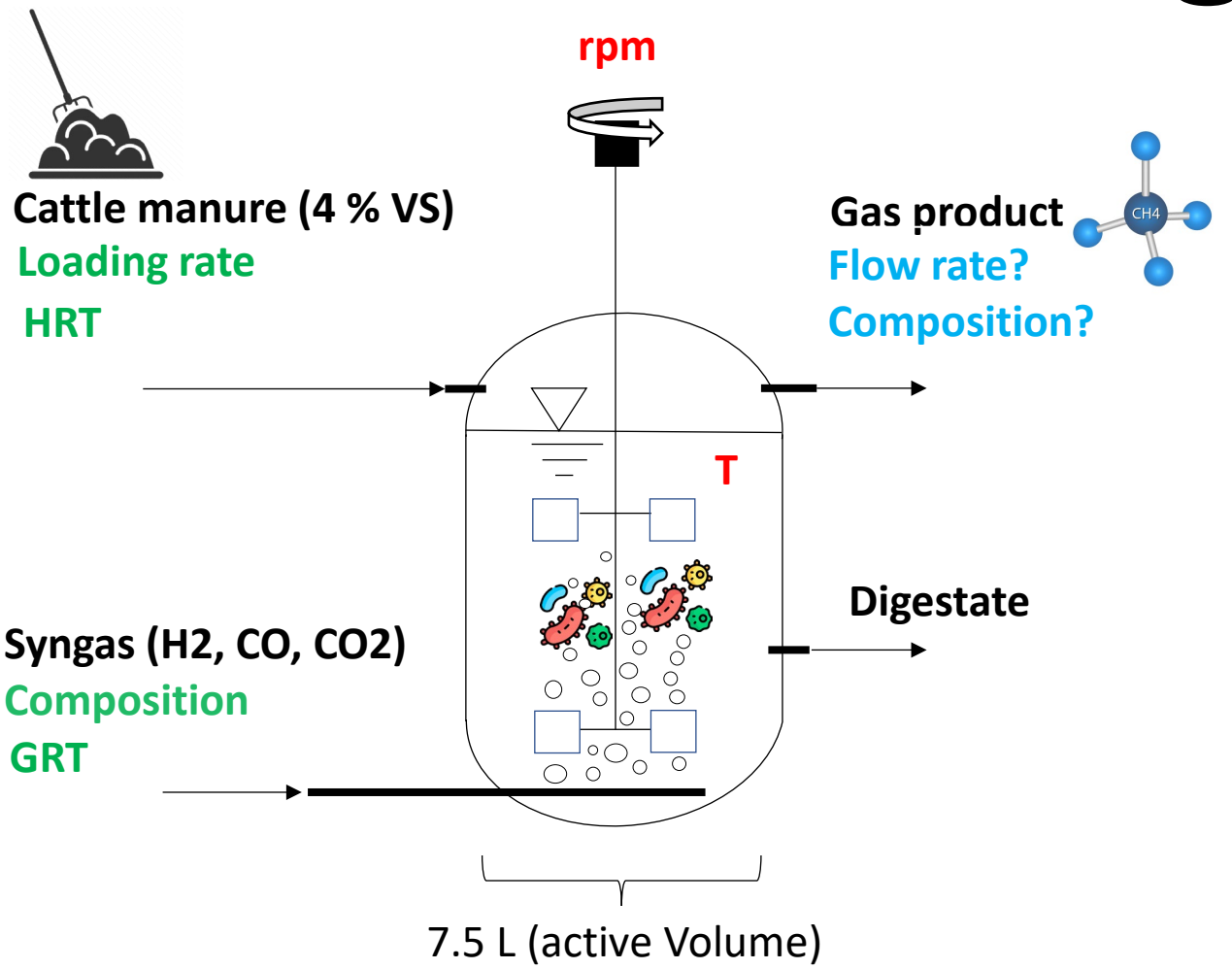
Average cost frac.: **34 %** **18 %** **9 %** **39 %**

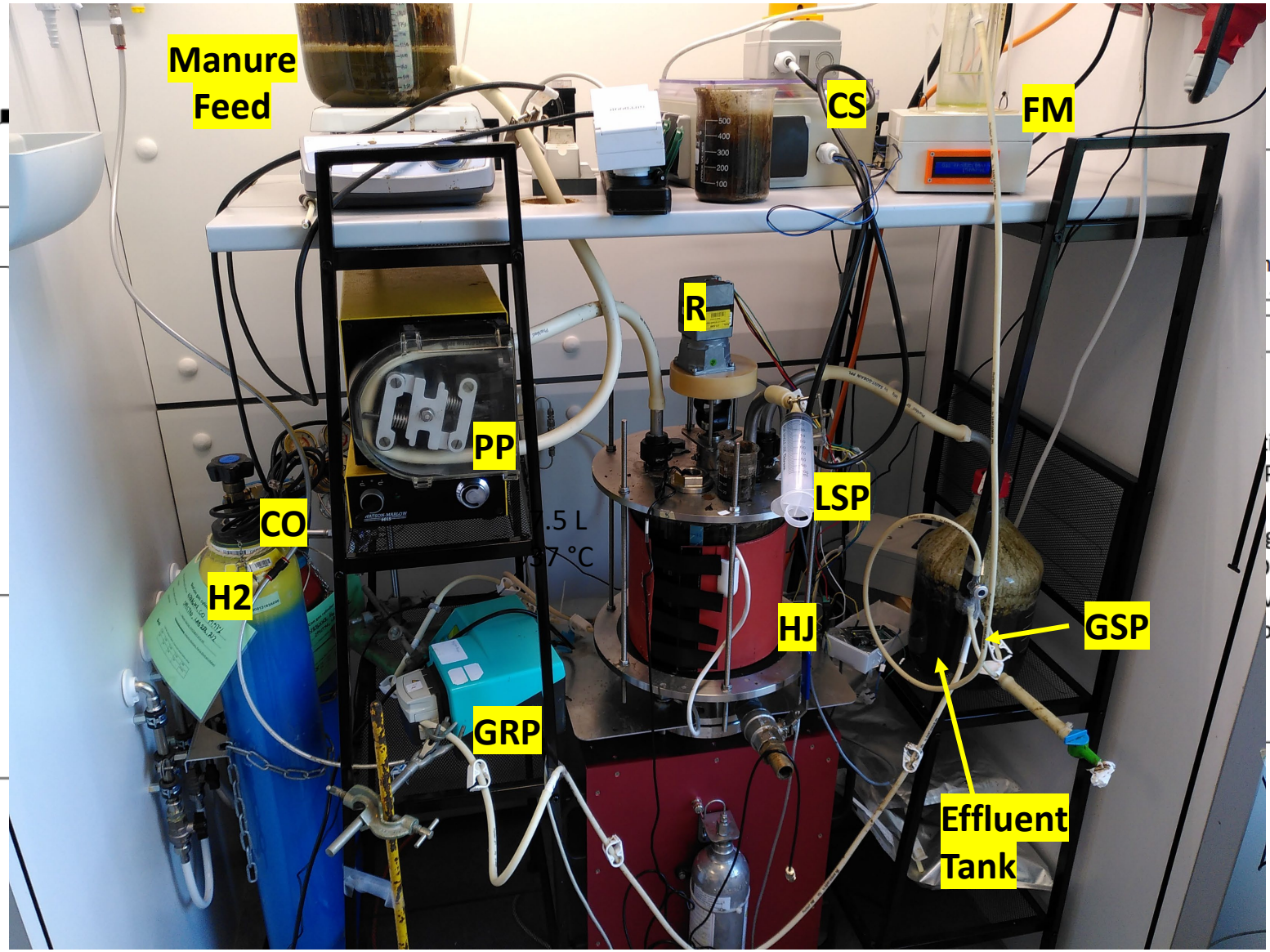


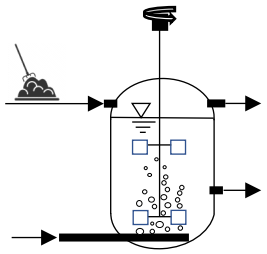


Biomass gasification (Gobigas plant, 2018): 112 €/MWh
Fossil (end user, 2018): 47 €/MWh


Biogas
Digestate
Biomass
Anaerobic digestion
Liquid products
Char
Syngas
Digestate
Biomass
Thermochemical process
Liquid products
Char
Syngas


rpm
Cattle manure (4 % VS)
Loading rate
HRT
Gas product
Flow rate?
Composition?
CH4
T
Digestate
Syngas (H2, CO, CO2)
Composition
GRT
7.5 L (active Volume)


Manure Feed
CS
FM
R
PP
LSP
CO
H2
HJ
GSP
GRP
Effluent Tank

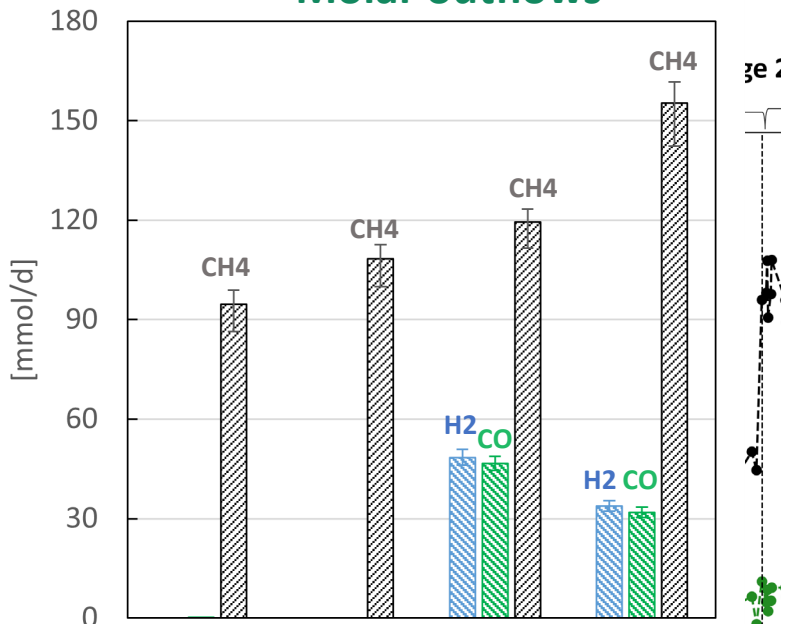


AD manure:
HRT= 20 d
OLR= 2 g_VS/(L*d)

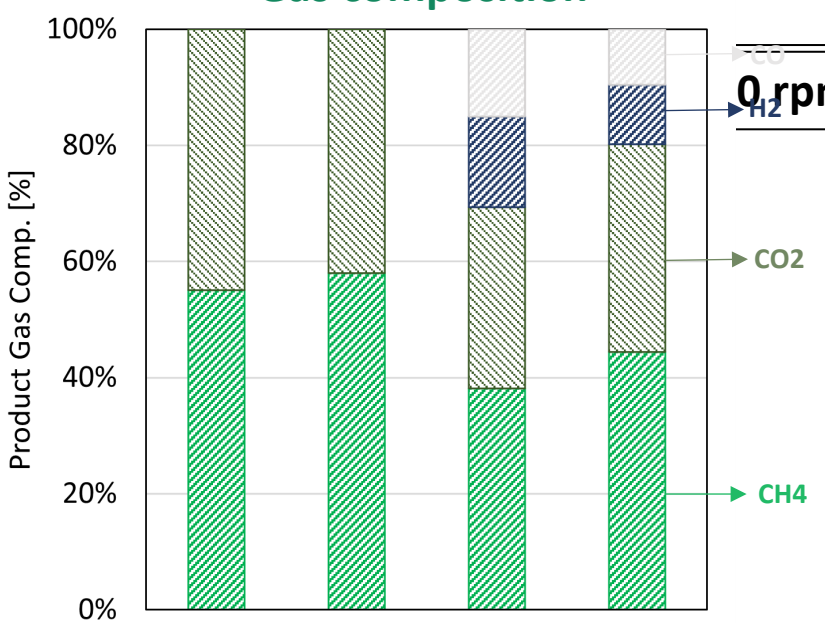
+ gas rec. 400 mL/min:

+ gas injection:
Comp.: 55% H2, 45% CO
Gas load: 0.432 L/(L*d)
GRT: 2.32 d

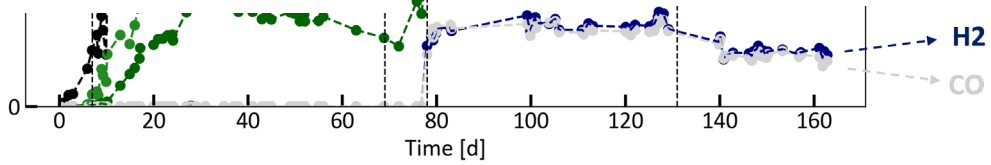
Molar outflows

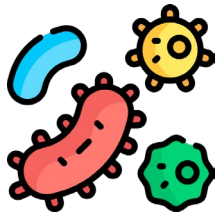


Gas composition

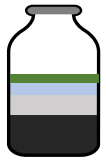


0 rpm

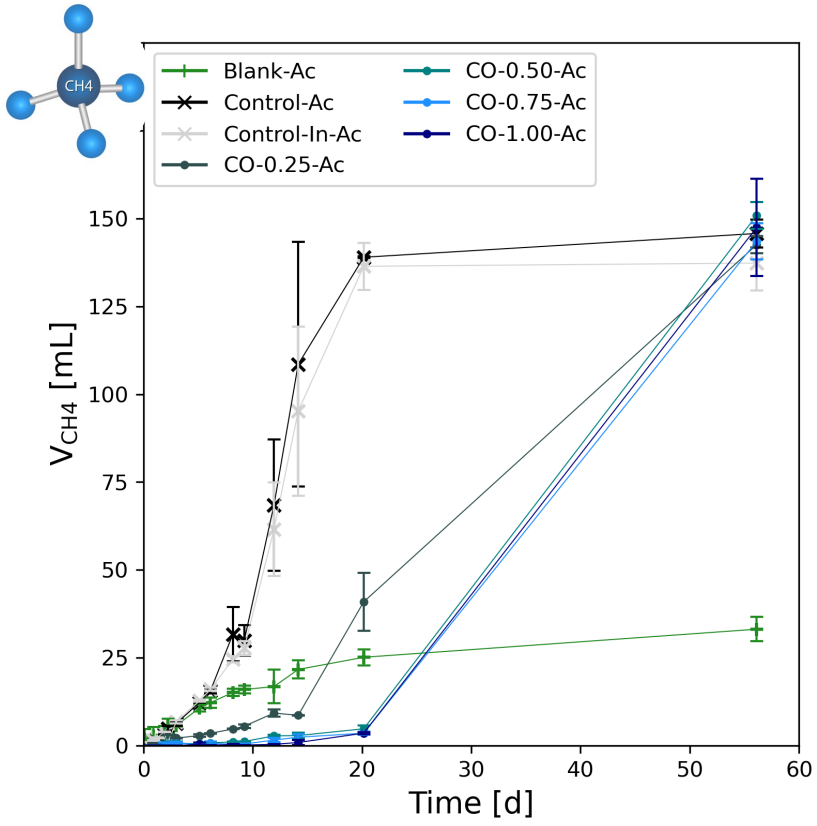




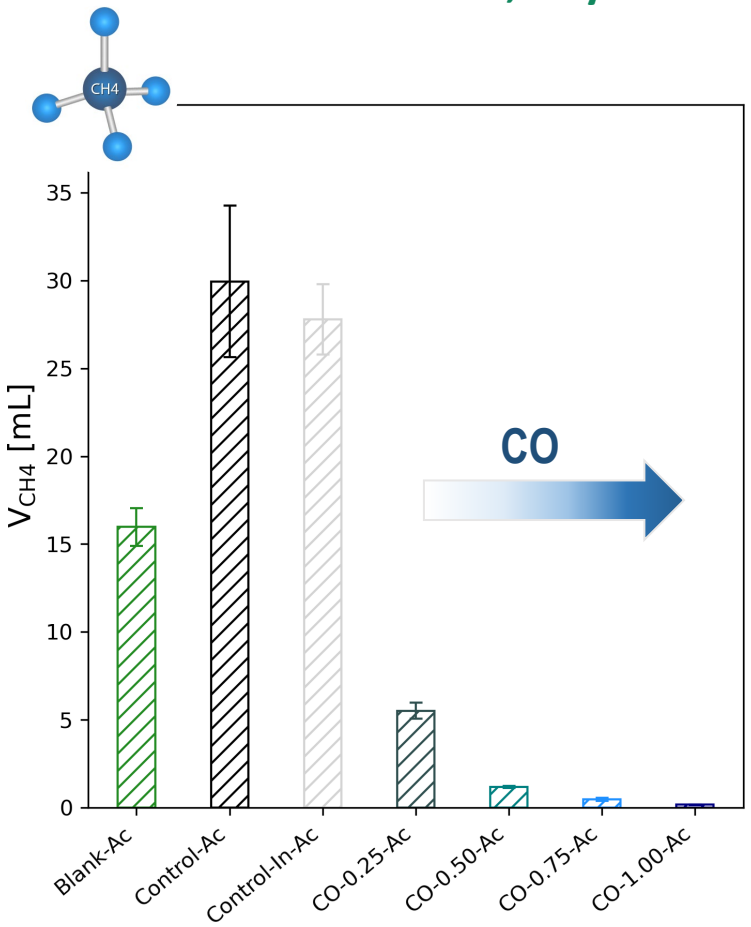
CO inhibition test aceticlastic methanogenesis



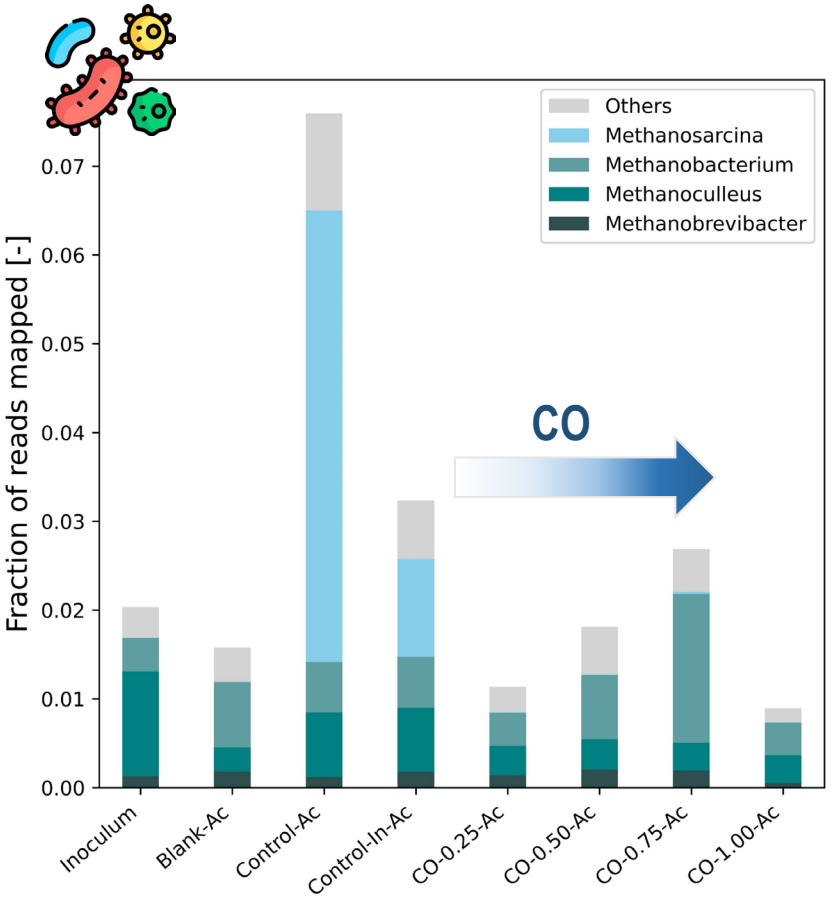
Cumulative CH4

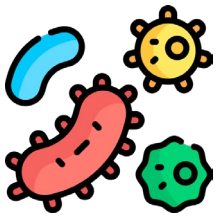


Cumulative CH4, Day 9

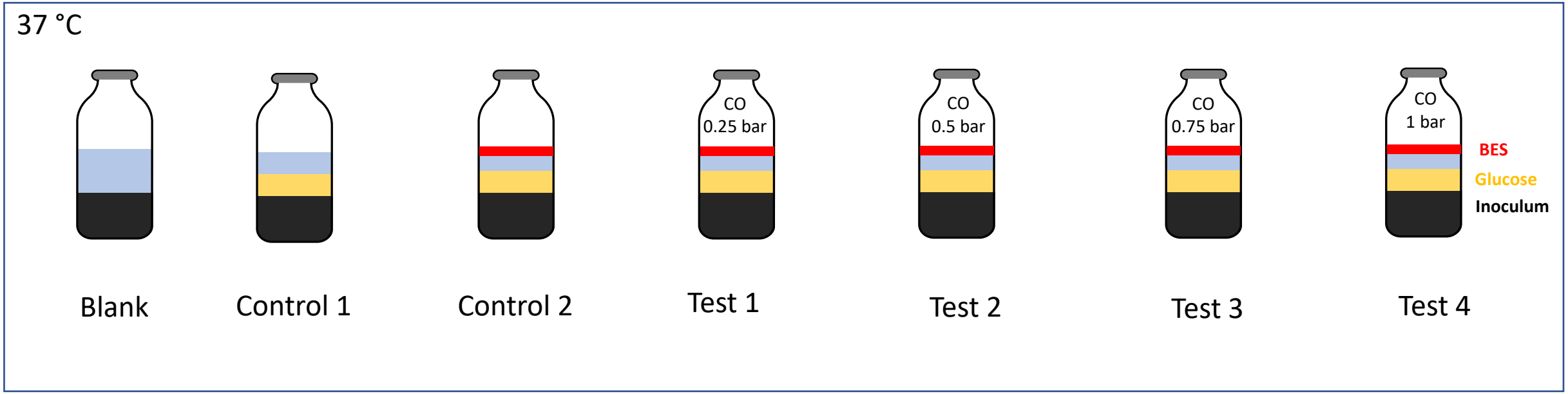


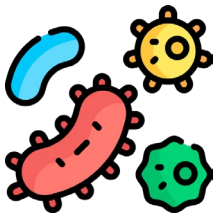
Archaea, Day 9





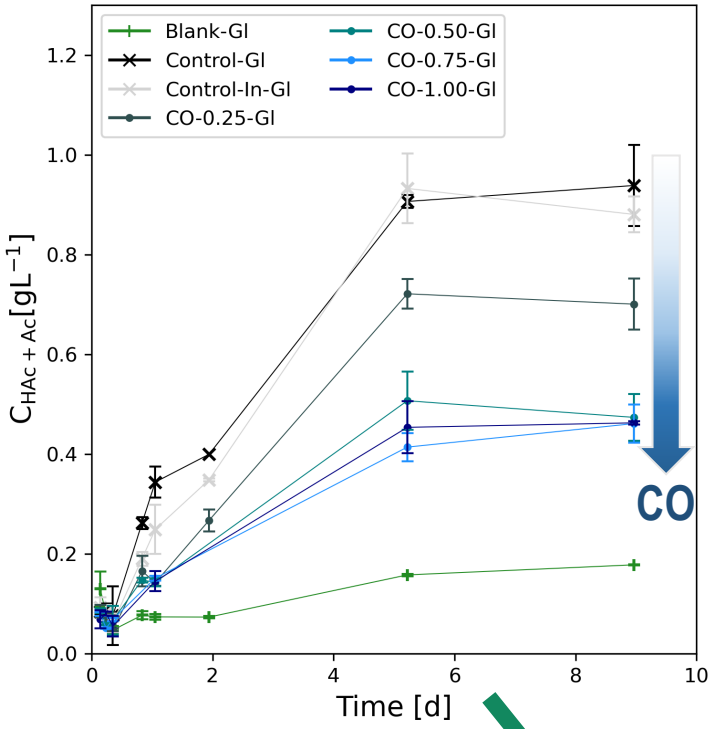
CO inhibition test glucose fermentation



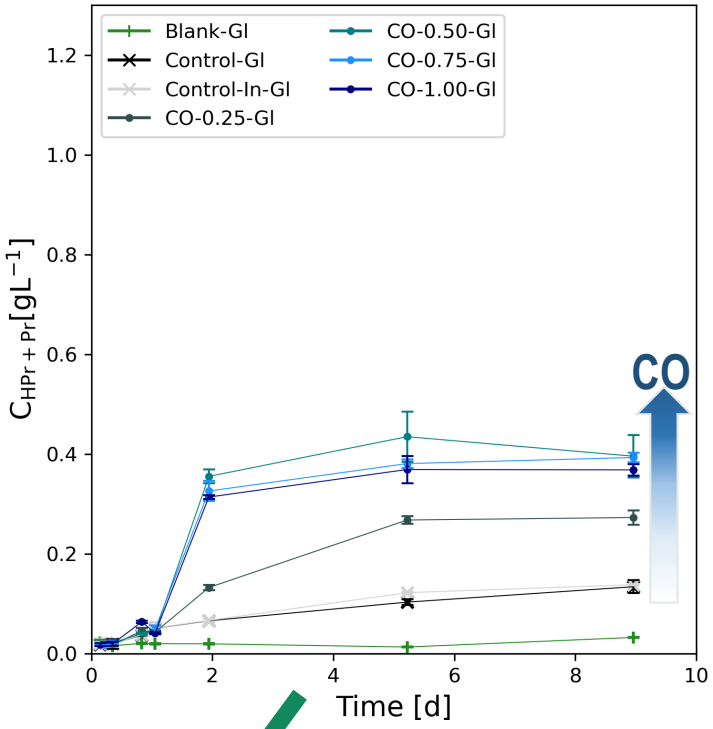


Cellulose
Enzymatic hydrolysis
Glucose
Glucose Degradation
Syntrophic acetate oxidation
CO
Propionic acid
Butyric acid
Acetic acid
H2
CO2
Butyrate oxidation
Homoacetogenesis
Propionate oxidation
Aceticlastic methanogenesis
CH4
Hydrogenotrophic methanogenesis
Biological conversion
Substrate/Product

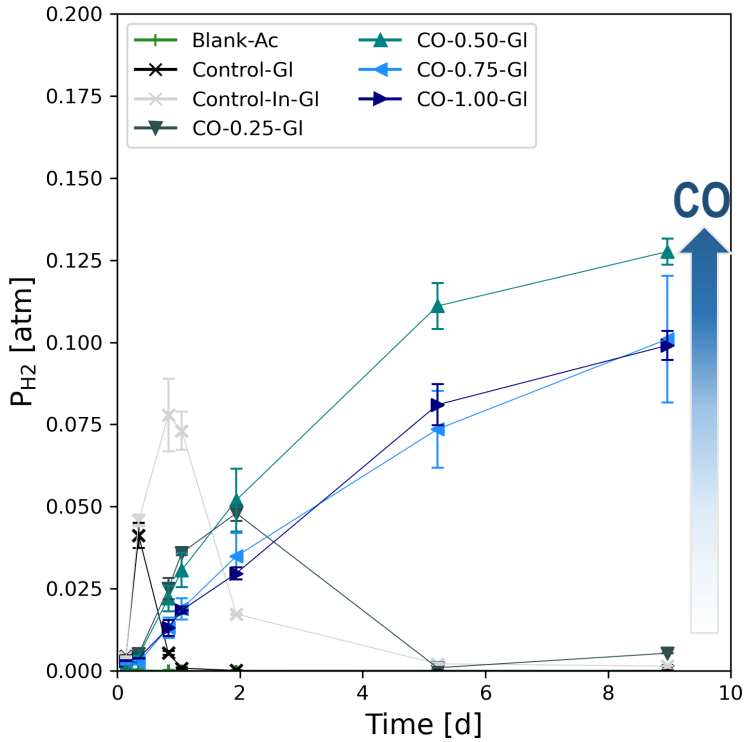
Acetate

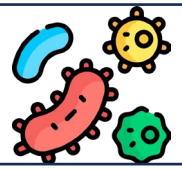


Propionate



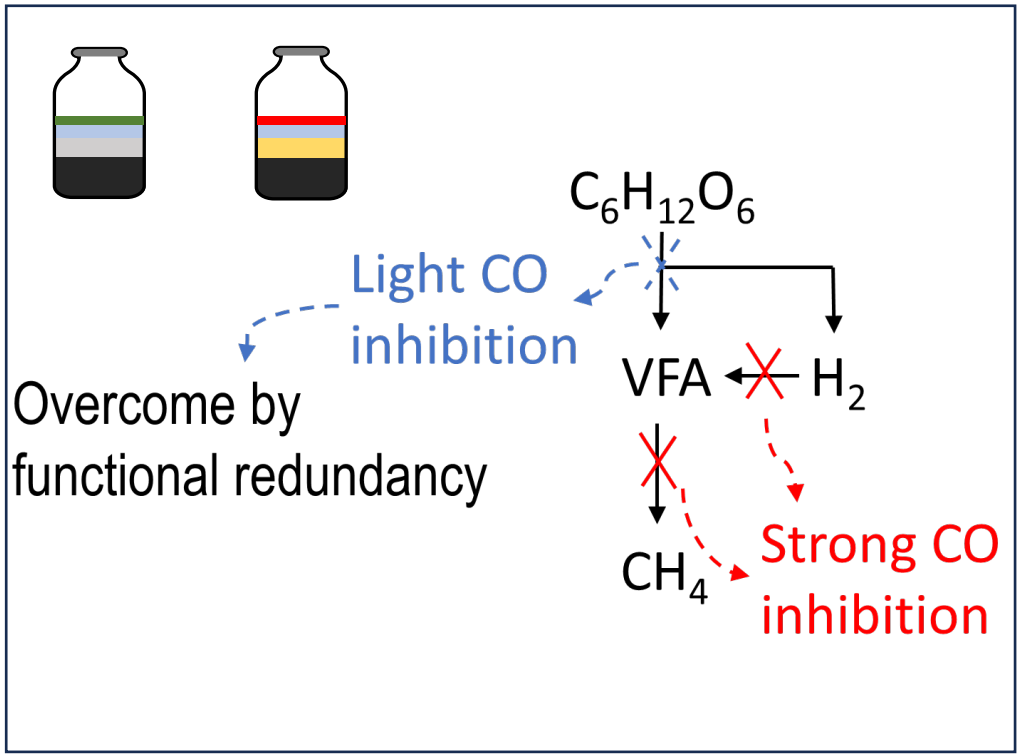
H2

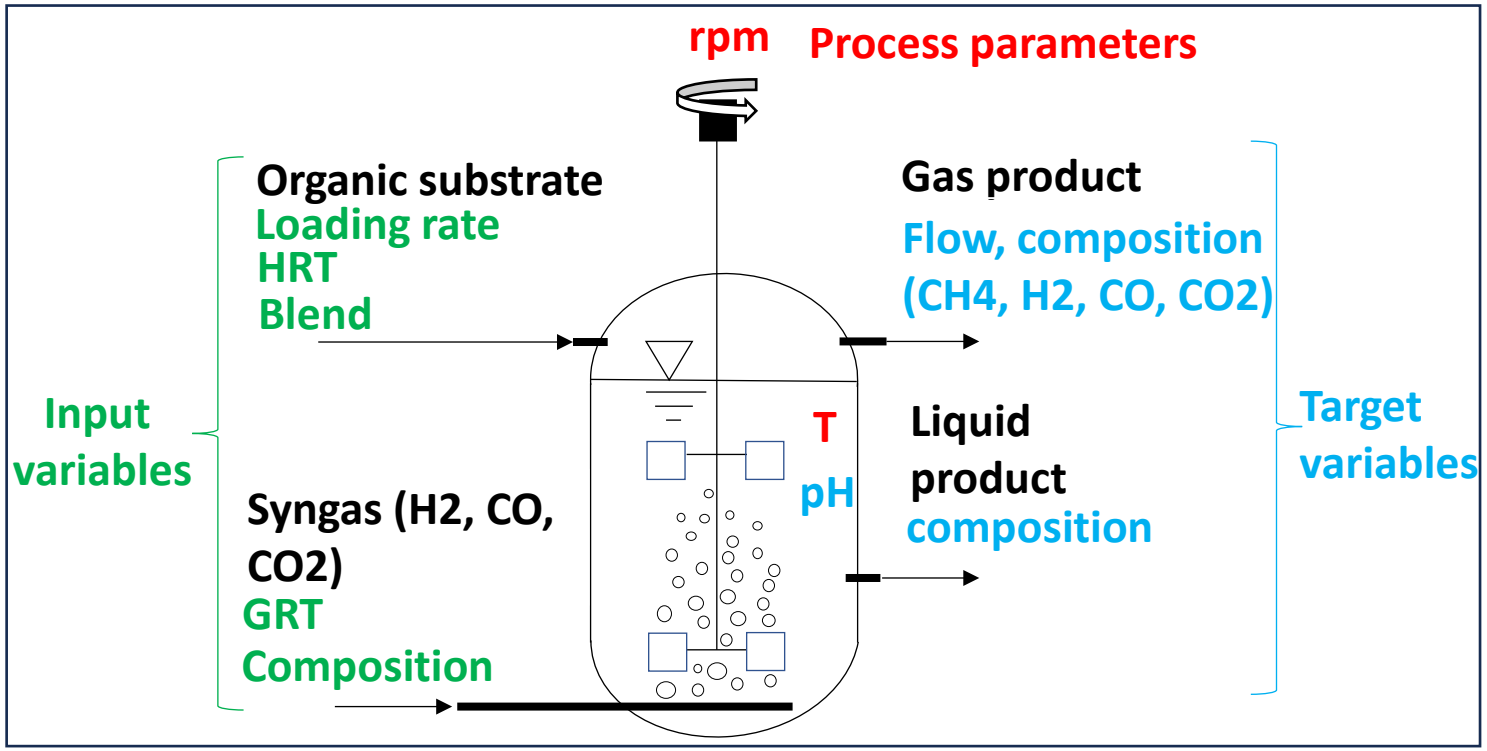




Functional redundancy effect
Enrichment Anaerotignum spp.

Graphical conclusion

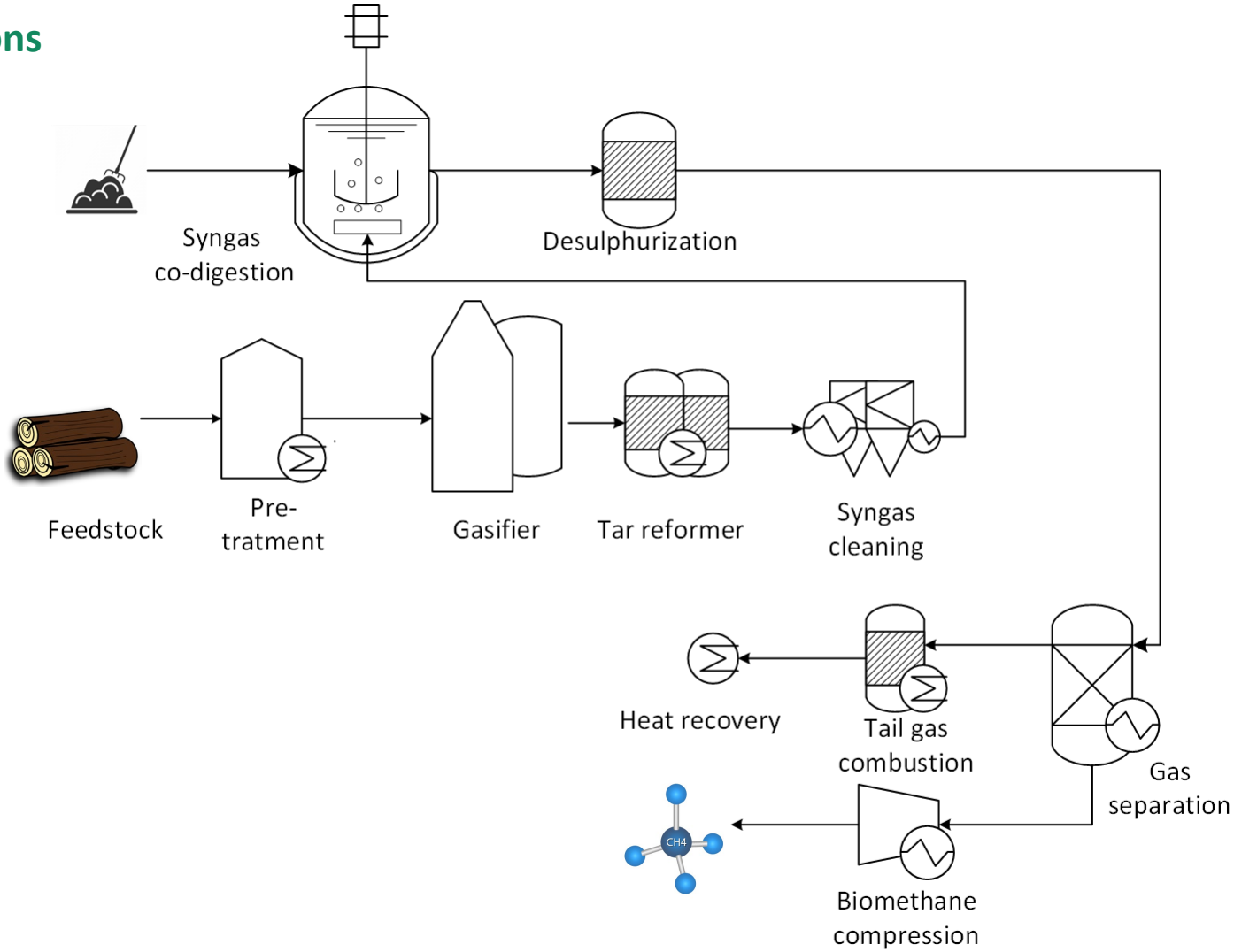




Take-home message

- CO inhibition is regulated by carboxydotrophic activity and mass transfer
- CO inhibition relevant in reactor start up and transient operation periods
- Outlook is reactor modeling and optimization

Future process evaluations



Thank you for your attention!

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