Platform for H_2 production from waste biomass with inherent negative emissions

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https://www.glamour-project.eu/

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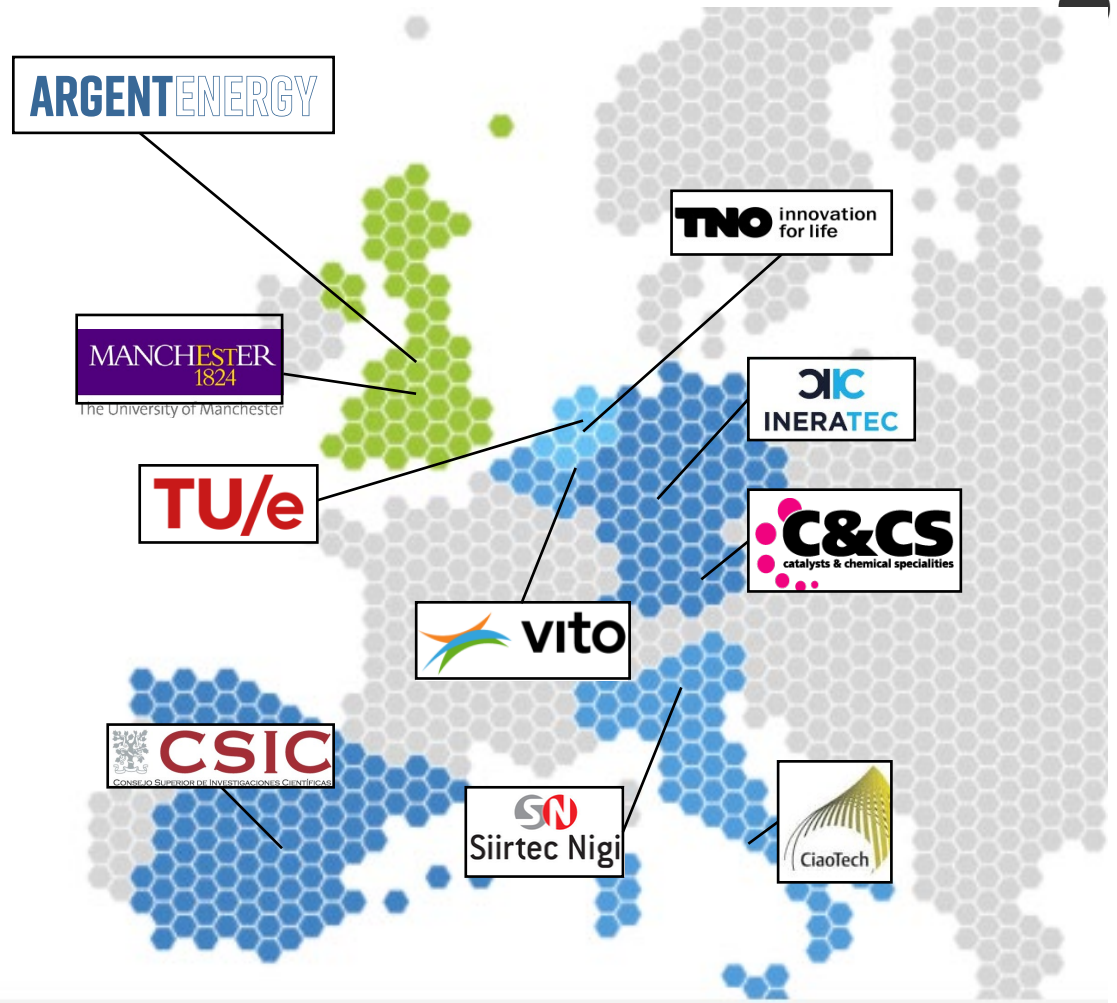
Summary

- Consortium
- Objectives
- Concept
- Findings

Consortium

- The GLAMOUR consortium includes 10 partners over 6 countries:
  - 2 Academic institutions: University of Manchester (UK) and Eindhoven University of technology (NL)
  - 3 Research centres: TNO (NL), VITO (BE) and CSIC (ES)
  - 2 SMEs: C&CS (DE) and INERATEC (DE)
  - 3 Large Industries: Argent Energy (UK), Siirtec Nigi (IT) and PNO-Ciaotech (IT)

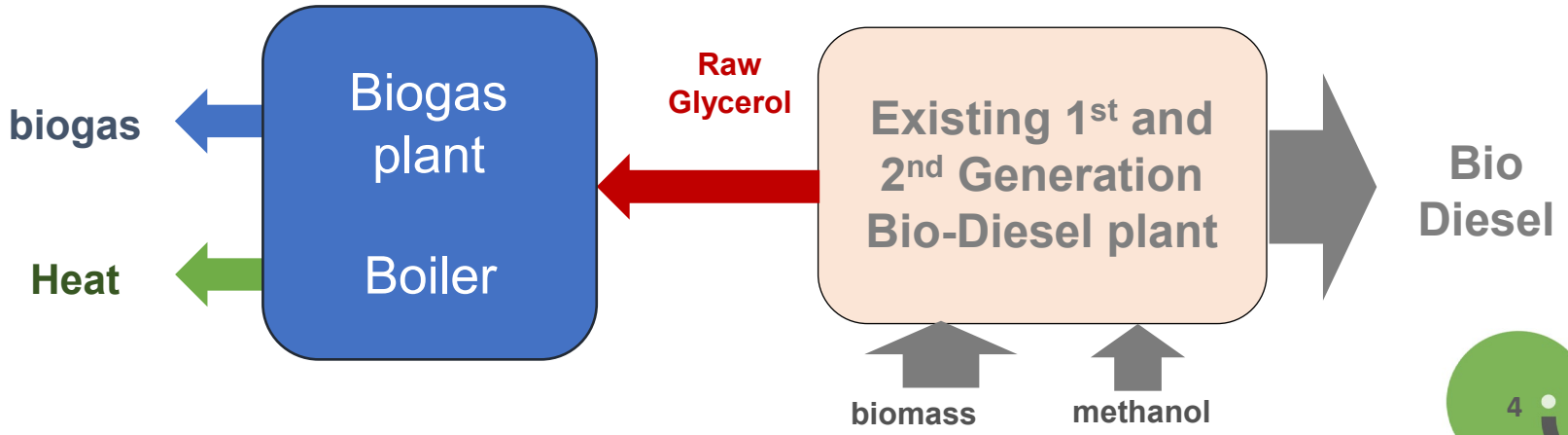


- The overall budget required is 4,989,130 €

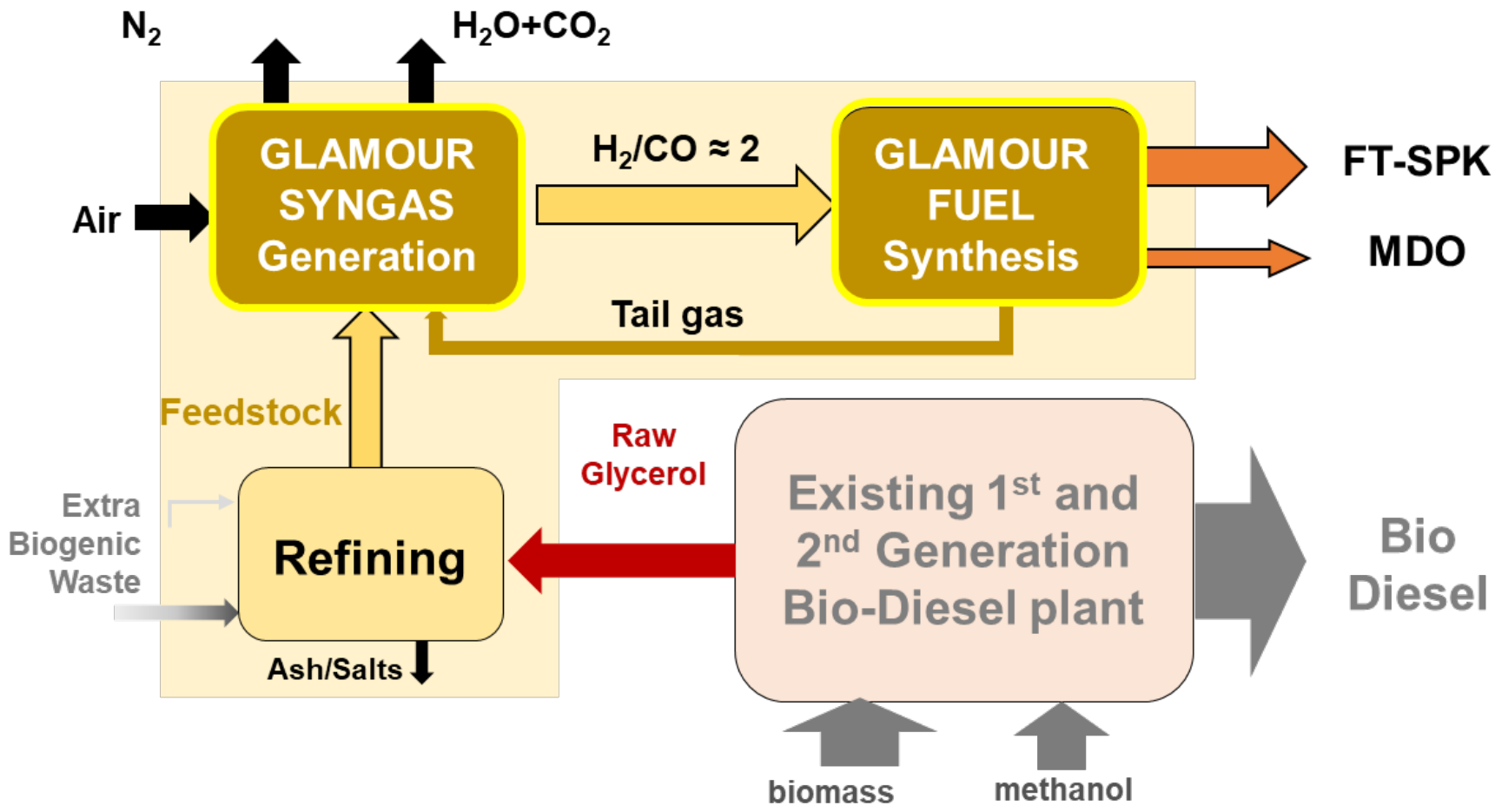
Advisory Board: Johnson Matthey, ENGIE, SKYNRG, TotalEnergies

GLAMOUR – The Research Idea

- As by-product, ≈1 kg of raw glycerol is formed every 10 kg of bio-diesel In bio-diesel plant
- Crude glycerol is separated with ≈ 50% purity since it contains methanol, water, catalyst residues, salts, free fatty acids, unreacted mono, di-, and triglycerides, methyl esters and other organic matter → few direct uses and low value



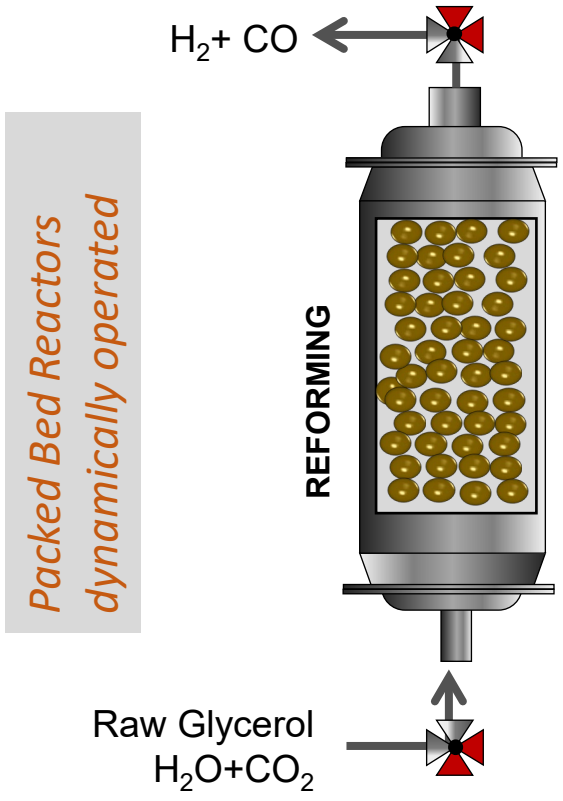
GLAMOUR – The Research Idea



GLAMOUR – SYNGAS Generation

REFORMING

- Packed bed reactor of supported Ni at high temperature and pressure
- Glycerol reacts with H_2O (and CO_2) to form syngas (a mixture of H_2, CO, CO_2, CH_4)
- The purpose of this process is to obtain a H_2/CO ratio close to 2 (as required in FT-synthesis) and minimise the CH_4/CO_2 content in the syngas



$$C_3H_8O_3 \leftrightarrow 4H_2 + 3CO$$

$$C_3H_8O_3 + 3H_2O \leftrightarrow 7H_2 + 3CO_2$$

$$CO + H_2O \leftrightarrow CO_2 + H_2$$

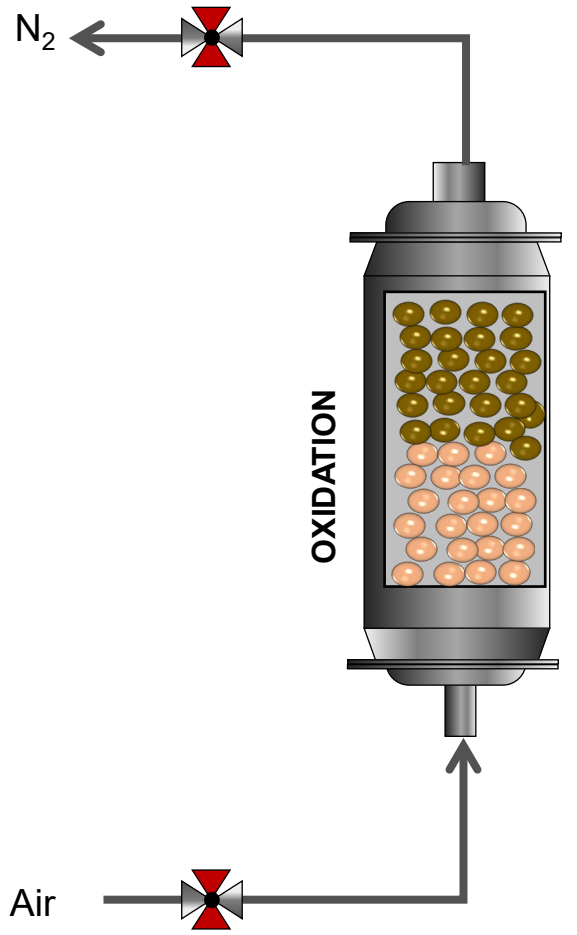
$$CH_4 + H_2O \leftrightarrow CO + 3H_2$$

GLAMOUR – SYNGAS Generation

OXIDATION

- Air reacts with the oxygen carriers (Ni - based materials)
- During the oxidation reaction (exothermic), the the bed temperature increases
- In this step the oxygen carrier inside the bed is oxidised

Packed Bed Reactors dynamically operated



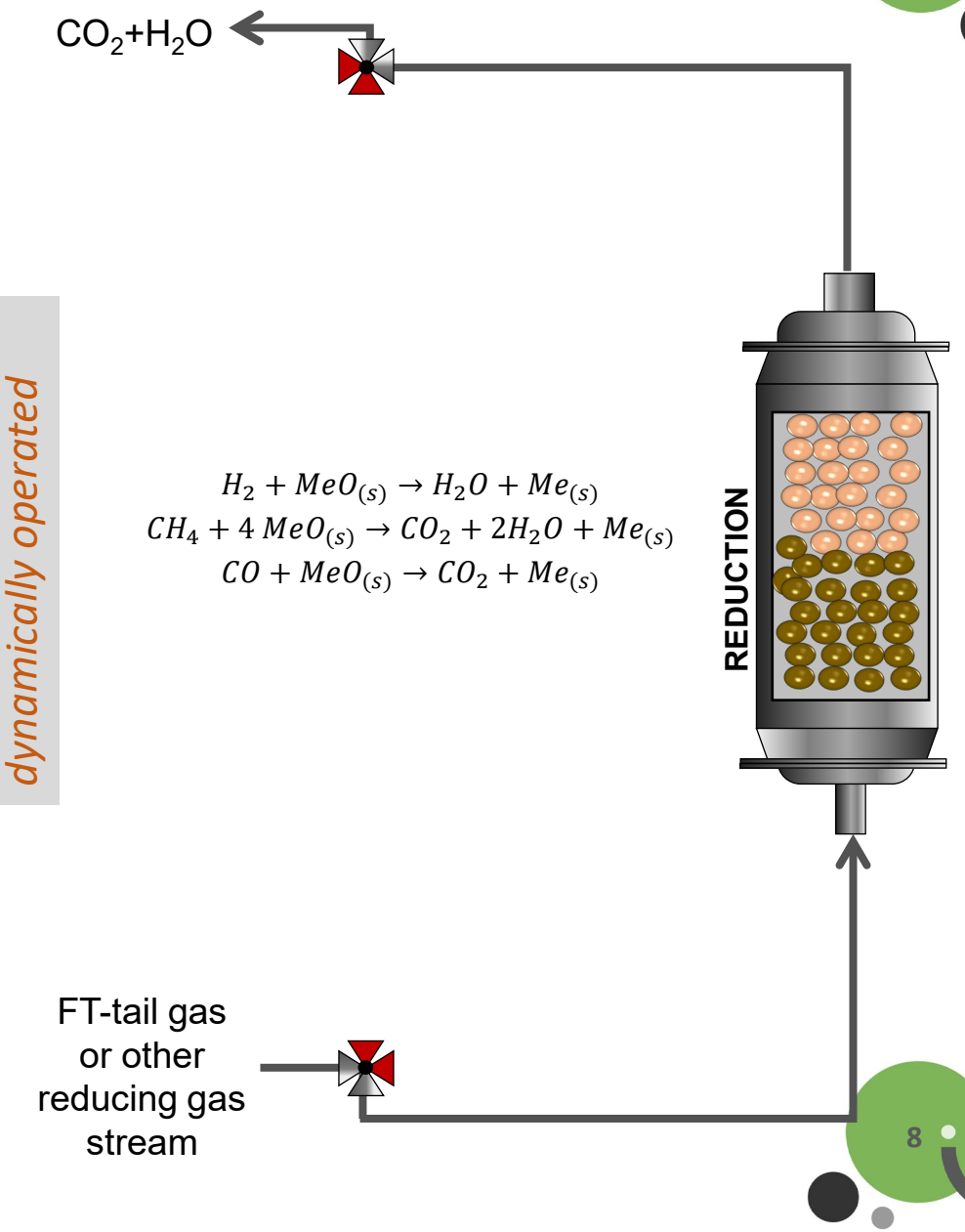
$$2Me_{(s)} + O_2 \rightarrow 2MeO_{(s)}$$

GLAMOUR – SYNGAS Generation

REDUCTION

- Tail gas available reacts with oxygen carrier to reduce it
- The purpose of this process is to reduce the OC and favour the production of a H_2O+CO_2 stream which can be separated downstream (further CCU)

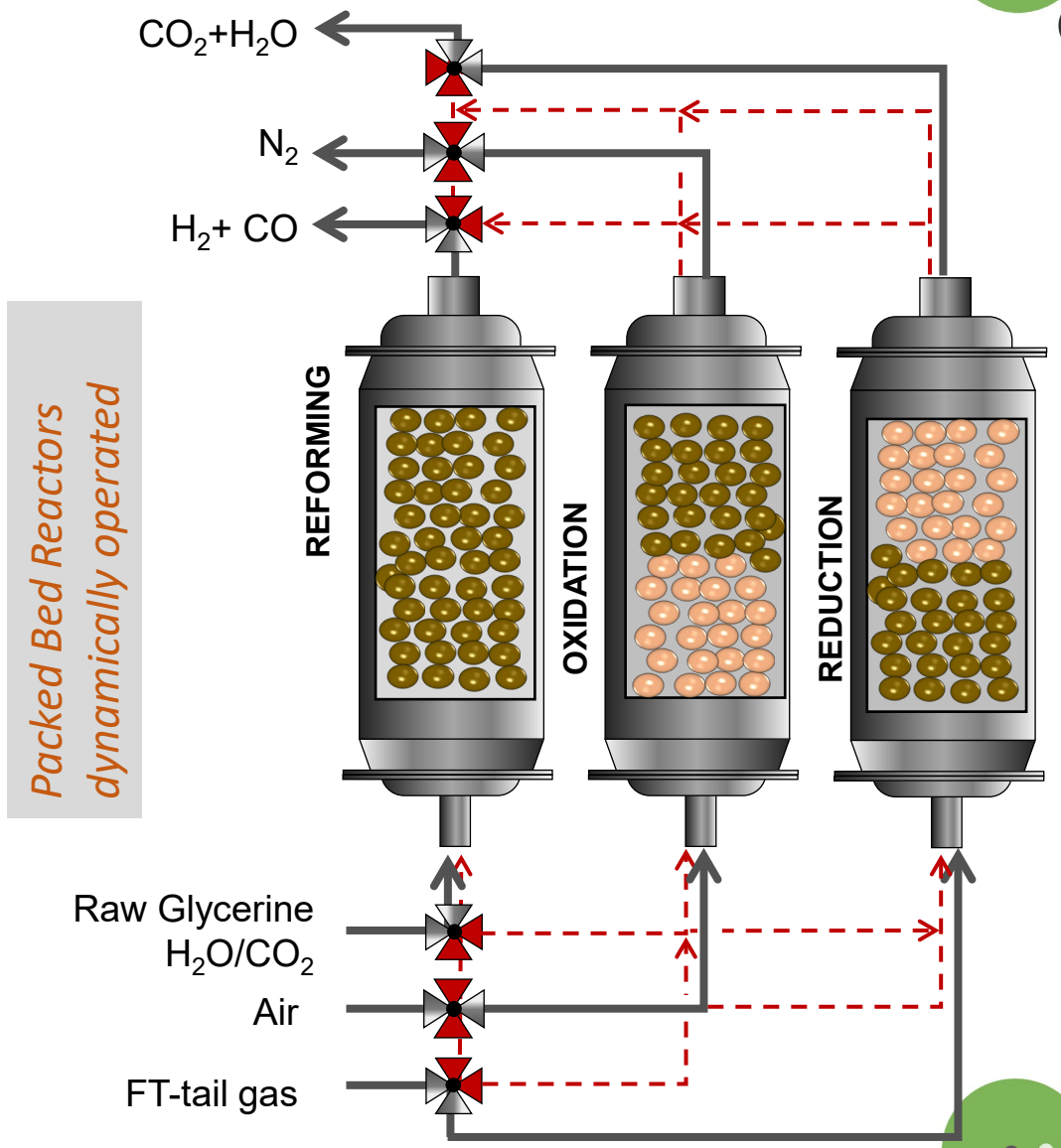
Packed Bed Reactors dynamically operated



GLAMOUR – SYNGAS Generation

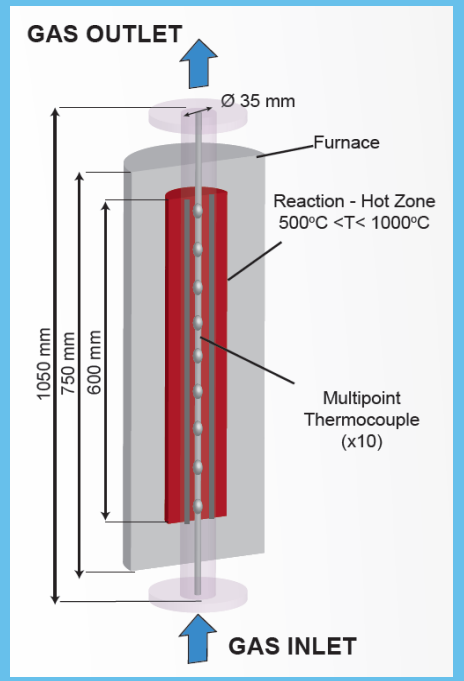
Overall Process

- The process occurs using sequentially operated packed bed reactors
- The solid remains in the bed and a system of switching valves is used
- The process can occurs at high temperature and high pressure.
- The process is thermally balanced

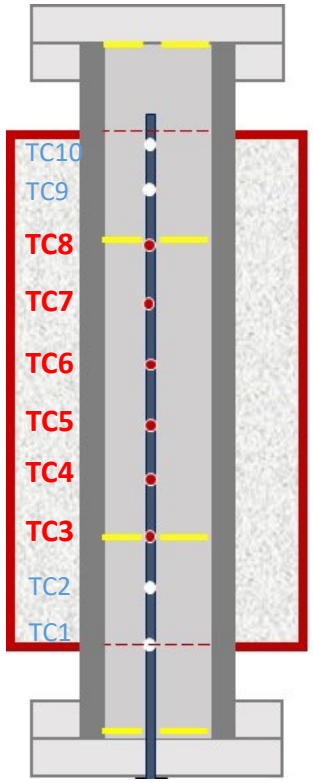


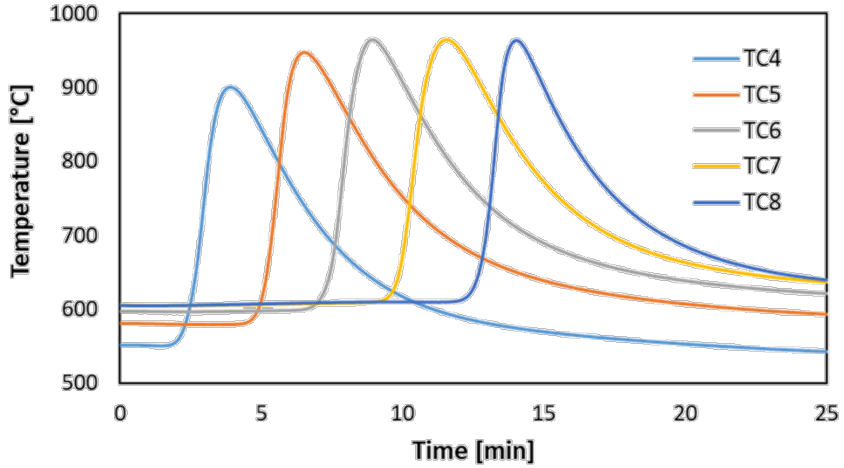
Kg Scale Reactor

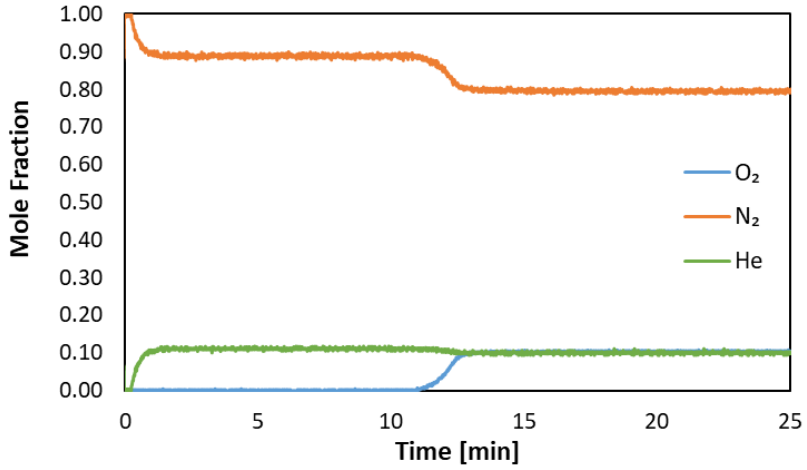
The temperature change during each stage is vital to understand
500g of a Ni based oxygen carrier was packed



Oxidation

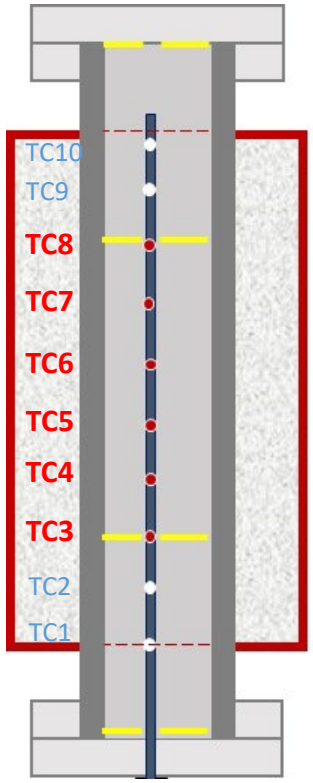


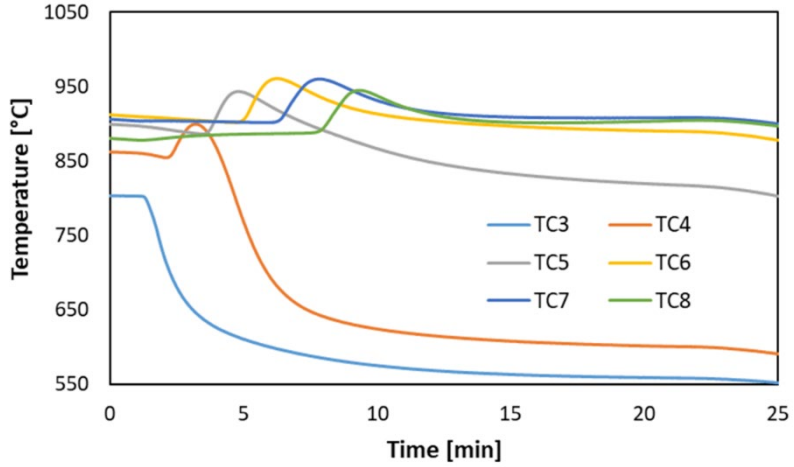


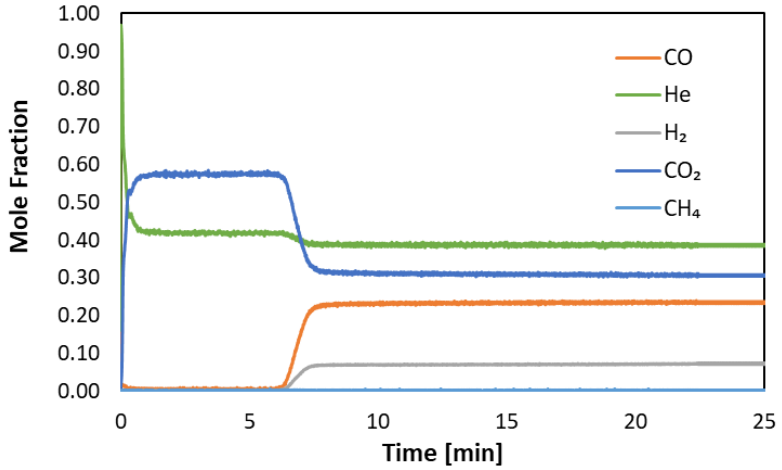


600°C 5 NL/min Air 4NL/min N_2 1 NL/min He 3 bar

Reduction and Reforming: Biogas

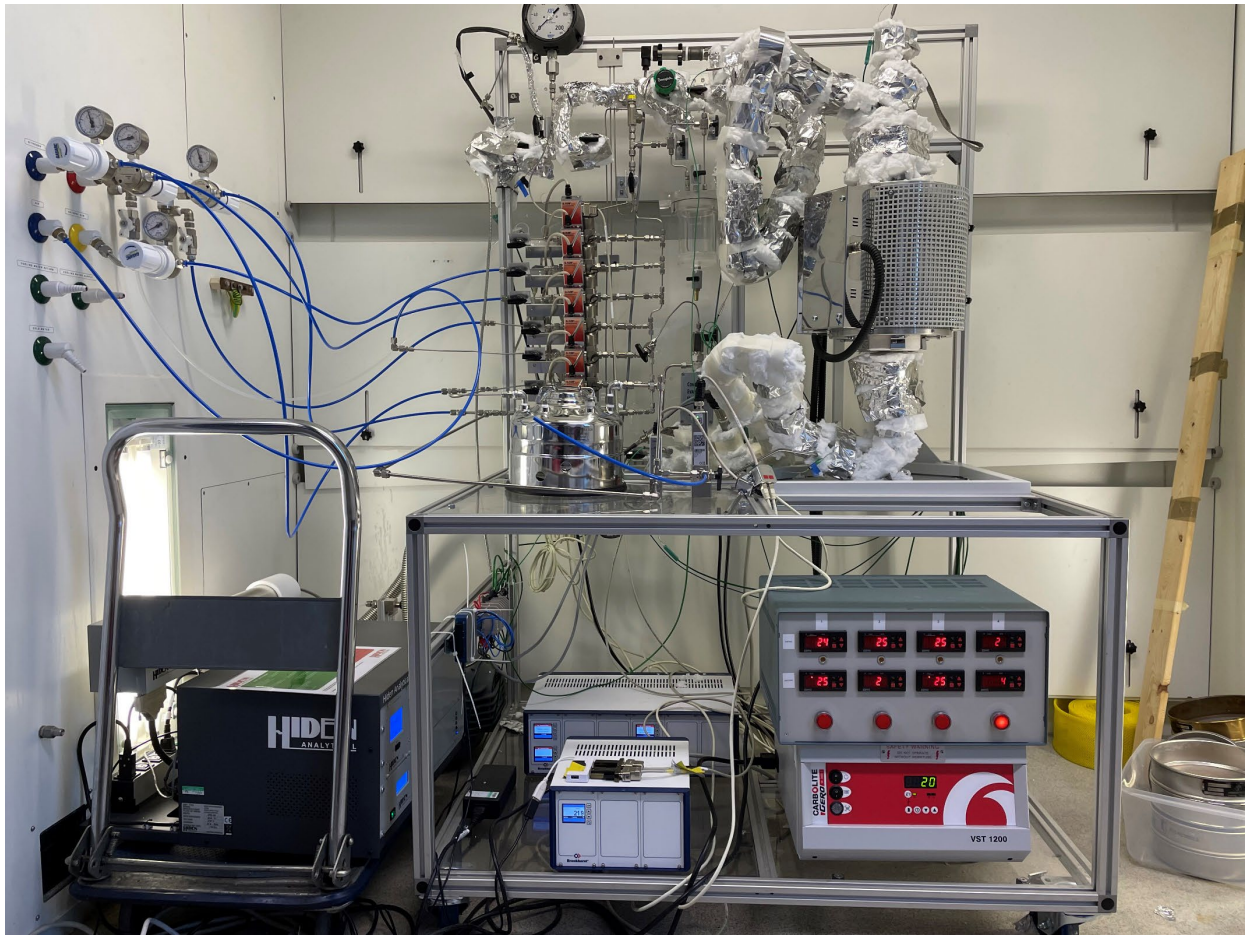






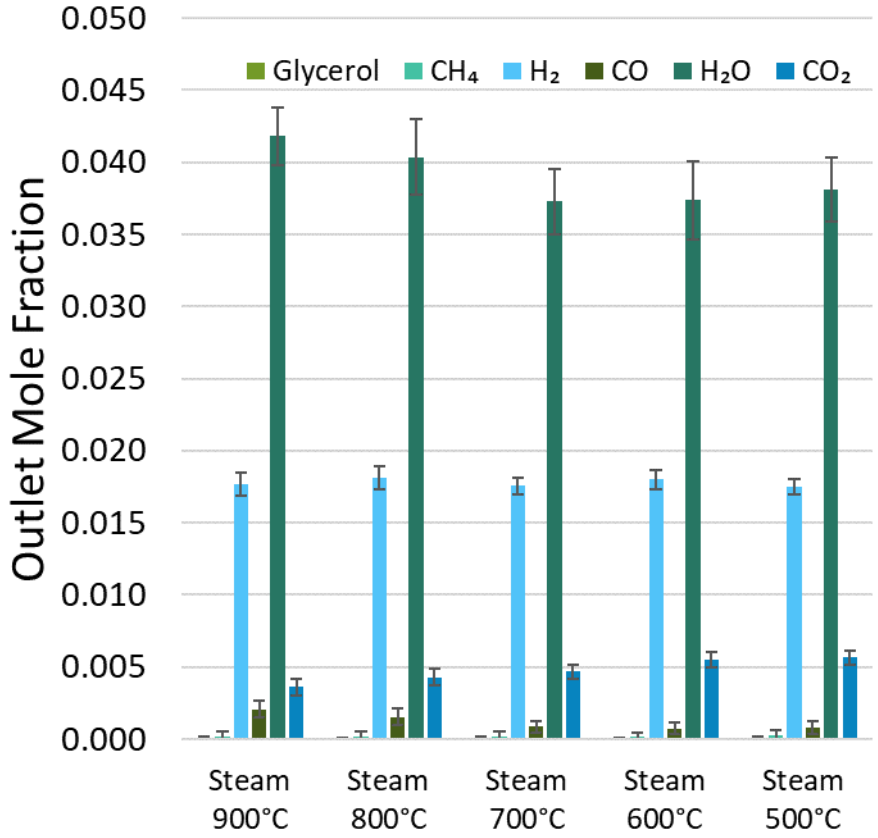
900°C 1 NL/min H_2 1 NL/min CO 7NL/min CO_2 1 NL/min He 3 bar

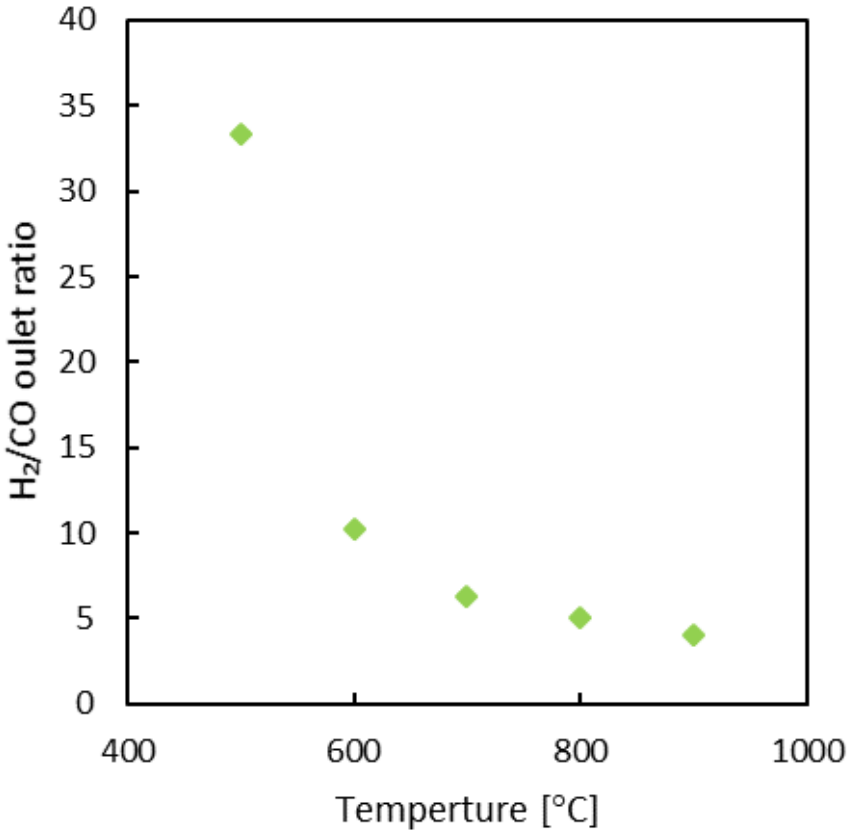
Equipment



A Packed bed of 5g of Ni based combined catalyst and oxygen carrier material

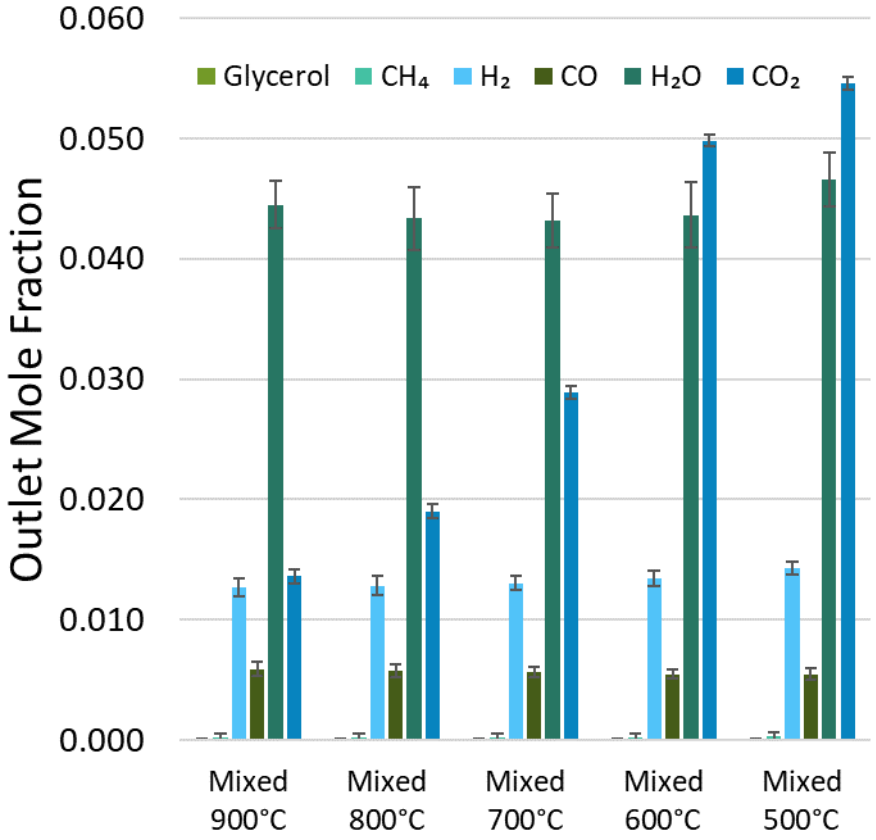
Steam Reforming

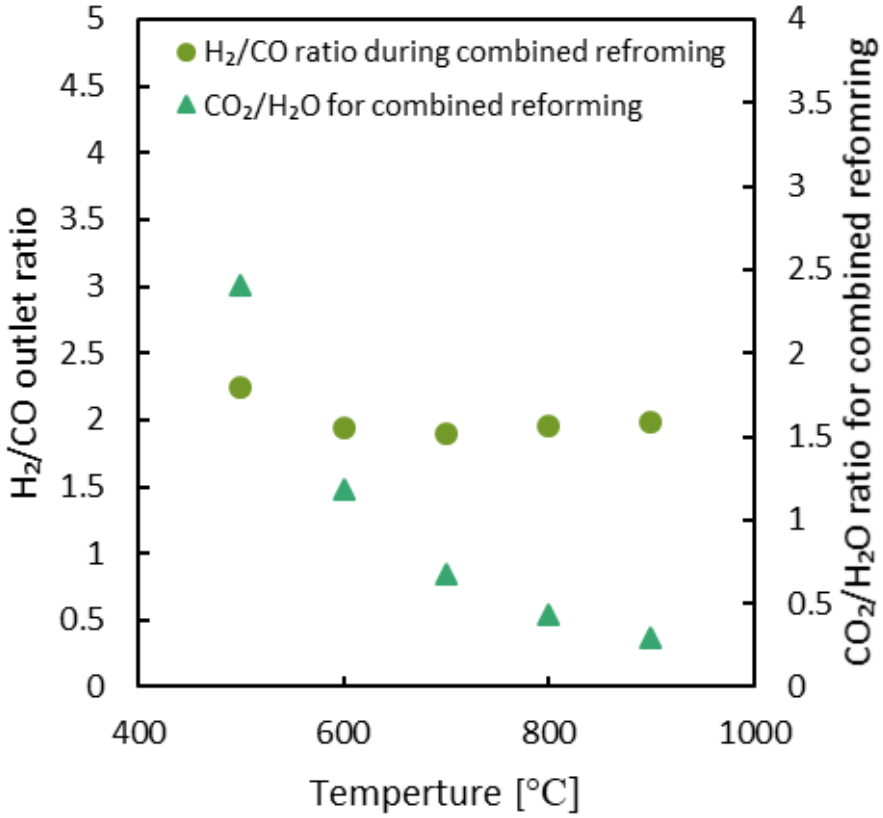




	Pressure	Temperature	Total flowrate	Composition
Reduction	1 bar_a	500-900 °C	1 NL/min	$C_3H_8O_3/H_2O$/He: 5/43/952

Combined Reforming





	Pressure	Temperature	Total flowrate	Composition
Reduction	1 bar_a	500-900 °C	Main flow 1 NL/min CO_2 flow 0.1-0.01 NL/min	$C_3H_8O_3/H_2O$/He: 5/45/950 CO_2 added to specification

Conclusions

- Chemical looping reforming of $C_3H_8O_3$ can produce both H_2 rich streams and feed stock for Fischer Tropsch reactors
- 100% conversion of Glycerol achieved
- System close to thermodynamic limit
- Future work should concentrate on larger reactor sizes to gain an understanding of the temperature profiles that would occur at industrial scales

GLAMOUR

Thank you

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If you have any question, please do not hesitate to contact us

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