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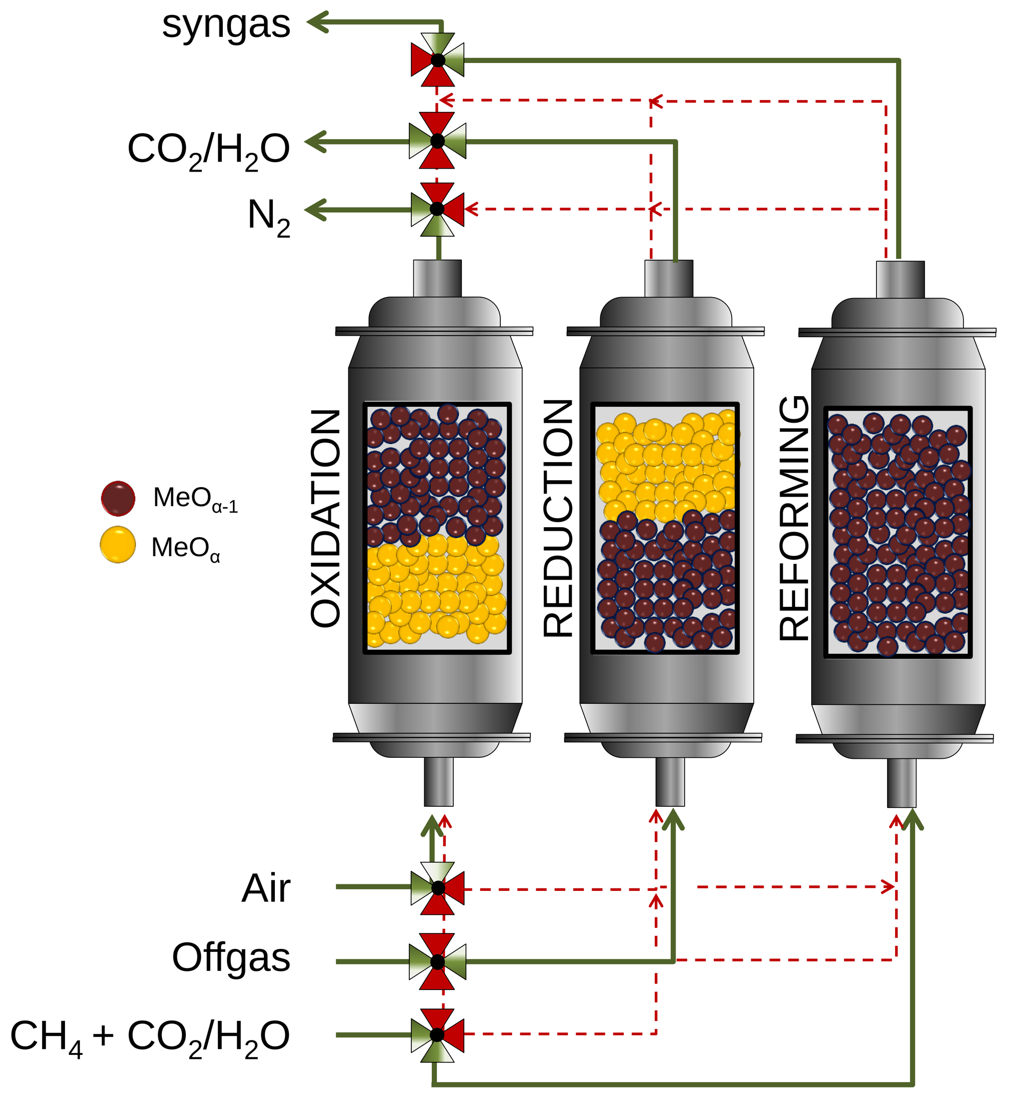
CLYCHING: CLean hYdrogen and CHemicals production via chemical loopING

(Chemical Looping Reforming with dynamically operated packed bed reactor)

CONCEPT



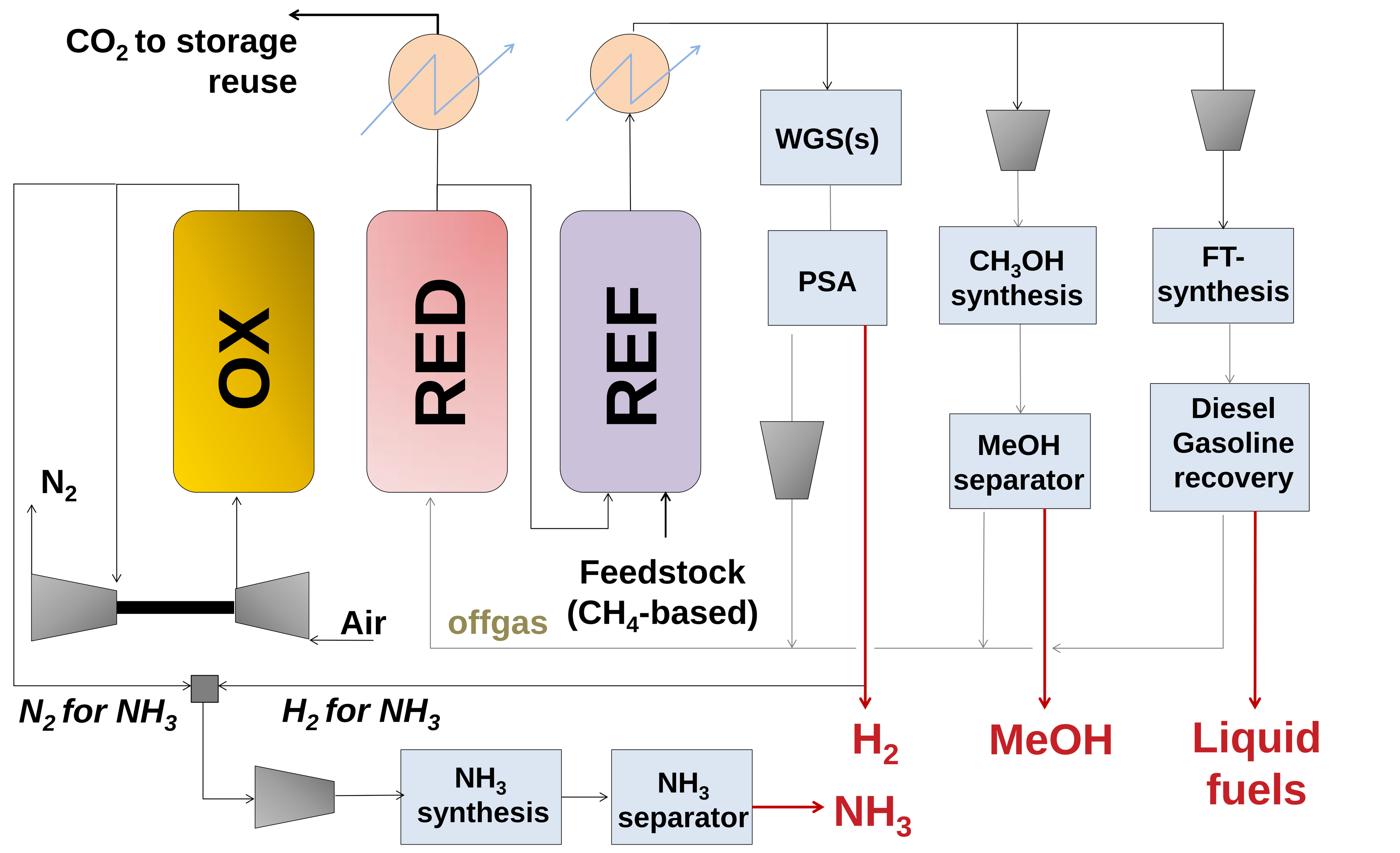
The process is divided in three steps [1]:

1) **Oxidation** with air

2) **Reduction** with a low grade fuel available in the plant

3) The heat stored inside the reactor during redox reactions is removed during the **steam/dry reforming**

INTEGRATION



In-situ air separation

Autothermal reactors (no furnace or externally heated processes)

Solvent-based CO_2 separation not required

Heat recovery occurs at **high temperature** facilitating efficient power generation (gas-turbine and state-of-the-art steam cycle)

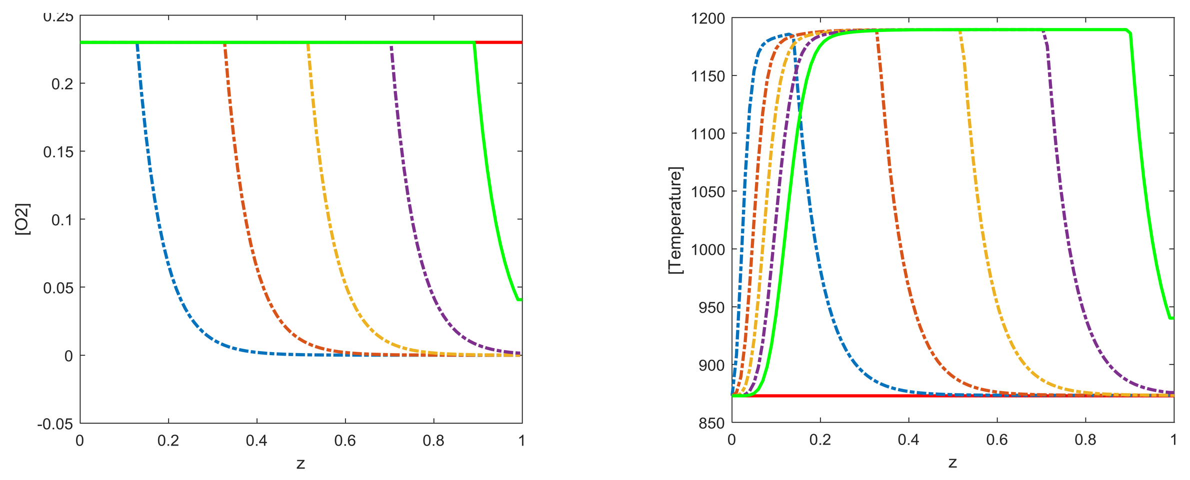
Key objectives

- Experimental demonstration at relevant operating conditions (up to 1000 °C, 10 bar, ≈5-10 $kW_{LHV,th}$) in an 1 kg reactor, using Ni, and Fe-based OCs;
- Design and modelling of a large scale plant and techno-economic assessment

Research highlights

Reactor model

Model verification completed with literature data



Process model

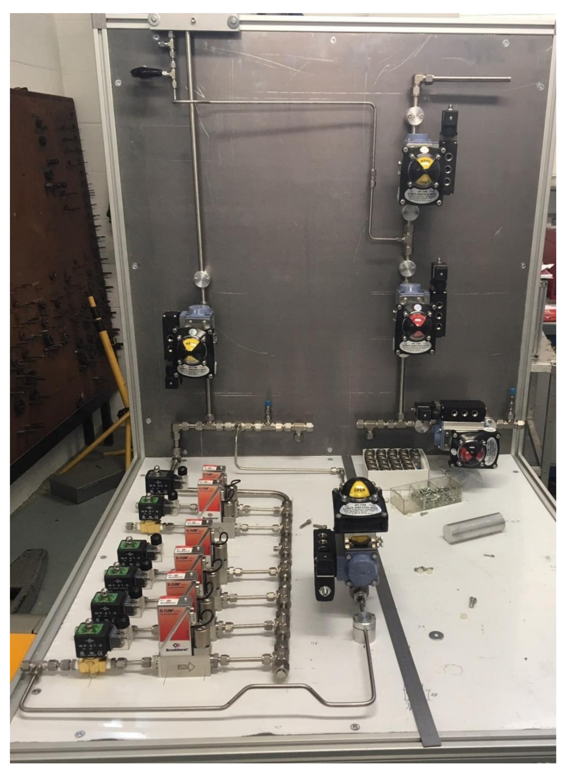
Expected performance based on existing literature [2]

performance#	Hydrogen	Methanol	Ammonia
Δ efficiency#	+4 to 14%	-1 to +3%	-3%
CCR	>95%	>95%	>90%
CAPEX cost#	-17 to +40%	-40%	-20%
Cost of production#	Up to -10%	Up to -20%	Up to -6%
CO_2 avoid. cost	55 €/t_{CO2}	-270 €/t_{CO2}	-13 €/t_{CO2}

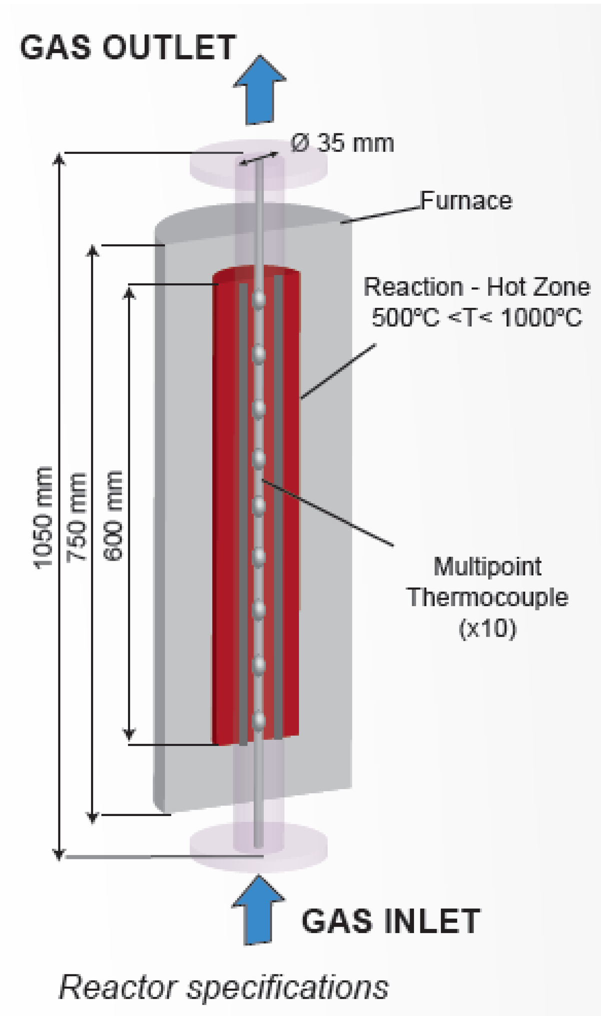
respect to competitive technologies

[1] V. Spallina, B. Marinello, F. Gallucci, M. C. Romano and M. Van Sint Annaland, *Fuel Process. Technol.*, 2017, **156**, 156–170.
[2] V. Spallina, G. Motamedi, F. Gallucci, M. Van Sint Annaland, *Int. J. Greenh. Gas Con.*, 2019, **88**, 71–84.

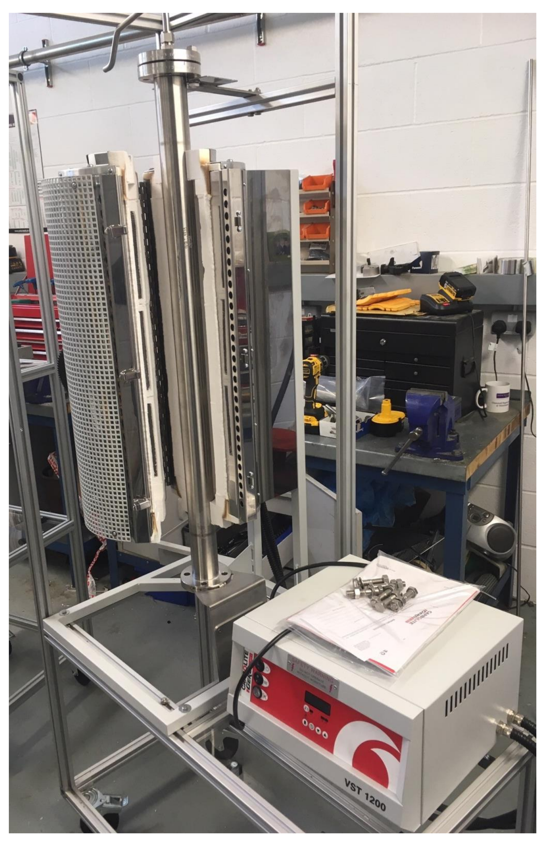
Experimental Facilities



Feeding system
Gases: up to 30 nL/min
$CO/CO_2/N_2/H_2/CH_4$/He/Air
H_2O is produced in a steam generator



Reactor specifications



Reactor
Material: stainless steel (253-MA)
Temperature: up to 1000°C
re: up to 10 bar (upgrade to 20 bar)
Capacity: Up to 1 kg materials

Next steps

- The **model validation** against experimental results
- **React and process optimisation** and comparison with benchmark technologies
- Implementation of chemical looping for **small-scale processes with other related feedstocks**
- Combination of Chemical Looping and other petro-chemical processes to exploit the combination of **exothermic and endothermic reactions**

Key researchers: Alexandros Argyris, Christopher de Leeuwe
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