Demo 2 (Spain) – Production of methane from biogenic CO_2 and green hydrogen

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circe
CENTRO TECNOLÓGICO

FUELPHORIA WEBINAR 2 – 4th OF DECEMBER, 2025

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DEMO 2 overview

1. **Located** in **Spain** (Aragon region).
2. **Wine factory** with more of 1000 hectares of grape crops.
3. **DEMO** will target **CH_4 production** (Power plant and or Road transport).
4. **CO_2** will be taken from **fermentation process.**
5. **H_2** is currently produced by on-site **electrolyzer** (500L/h).
6. **TRL** initial 5 – Final **7.**

VIÑAS DEL VERO

FAMILIA GONZÁLEZ BYASS

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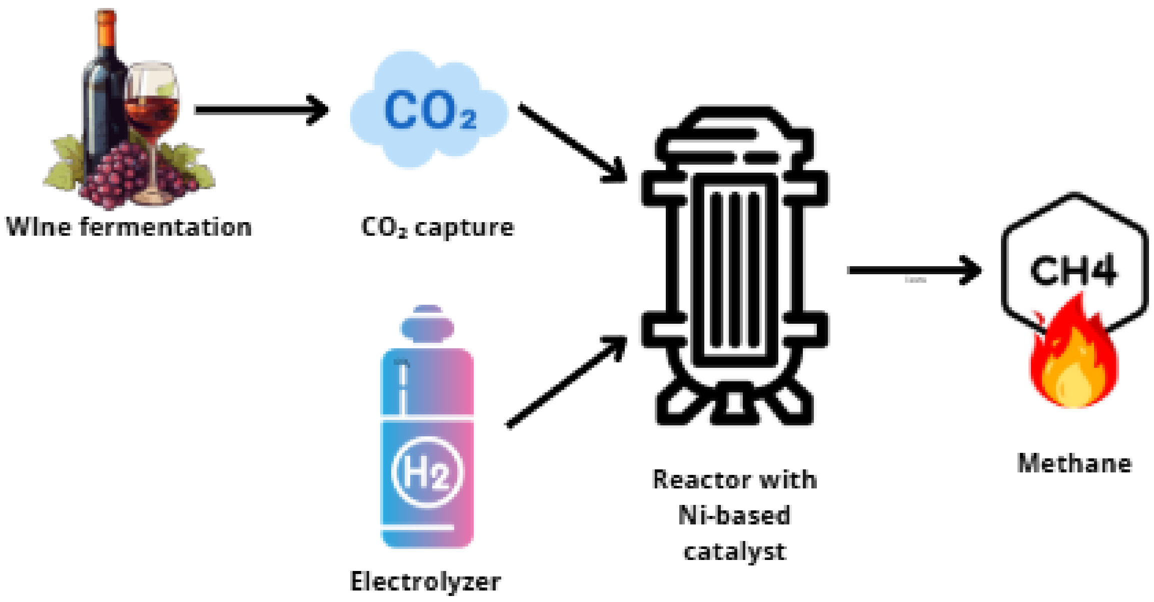
Aim of DEMO 2

- To utilize the captured CO_2 from the wine fermentation process, combined with green H_2, as feedstock for a methanation process that produces CH_4 by the Sabatier reaction.
- This is achieved using novel nickel-based catalysts.
- The CO_2 will be separated, purified from the fermentation gas, and stored for later use in the methanation process, where it will be converted into CH_4.
- The CO_2 generated during wine fermentation is carbon-neutral, matching the amount absorbed by the vines through photosynthesis.



Sabatier reaction

$$CO_2 + 4H_2 \longleftrightarrow CH_4 + 2H_2O$$

$$\Delta H_r^0 = -165{,}1 \text{ kJ mol}^{-1}$$

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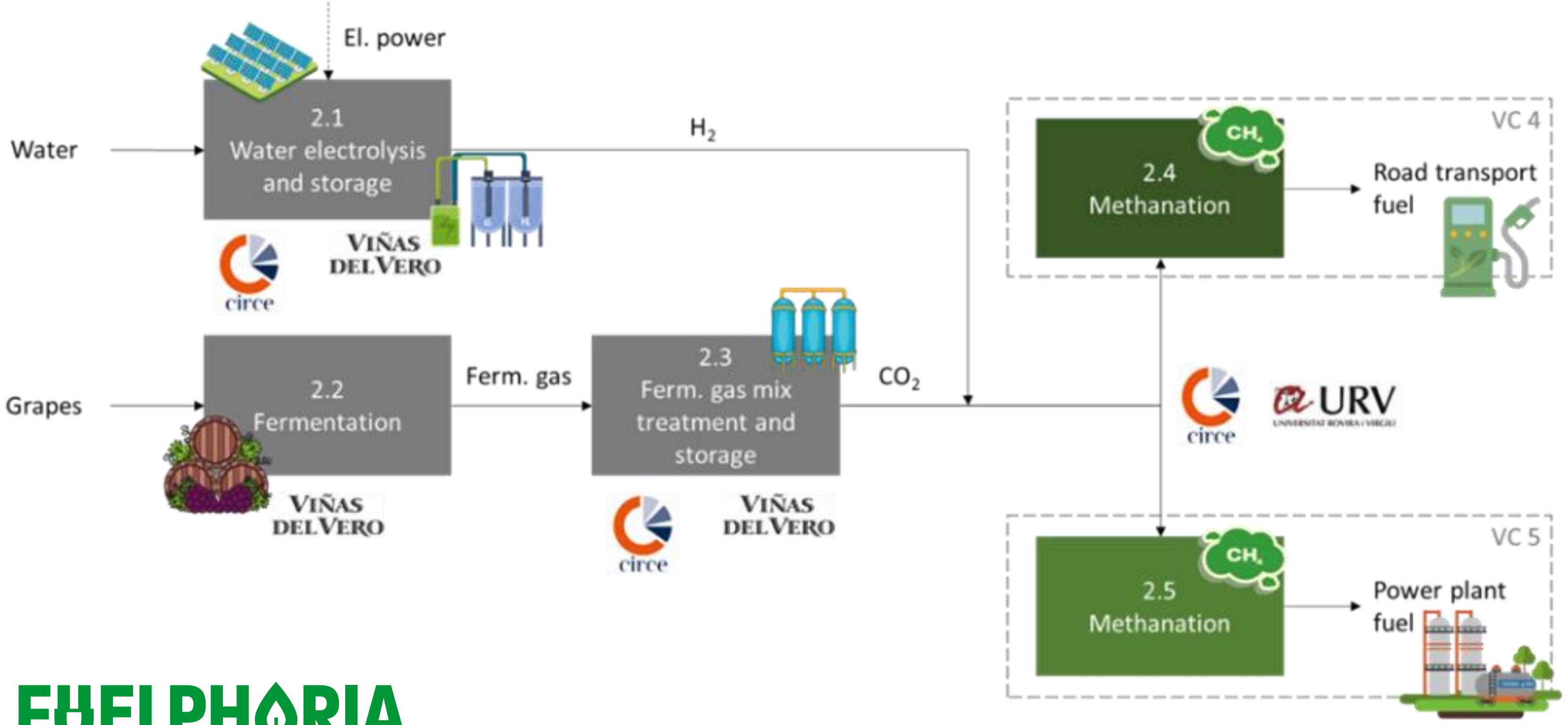
Project Partners and DEMO targets

- Viñas del Vero (VdV): Host site; provider of CO_2 and H_2 feedstock.
- CIRCE: Responsible for methanation process development and integration.
- URV (University Rovira i Virgili): Development of catalysts and methanation reactor.



DEMO TARGETS

- H_2 production: 500 L/h, 99.94% purity, 30 bar pressure.
- CH_4 production: 2.2 kg/day → 780 kg/year.
- CO_2 utilization: 0.4% of winery's annual emissions.

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CO_2 capture unit

Captured CO_2

The captured CO_2 in this harvesting period (from the 20th of August to the 9th of September) has been 17 Tm. From this, only 800 kg are going to be used for potential methanation.

- **99.95 %** of purity.
- CO, hydrocarbons, ethanol and water are the main **“impurities”.**
- **Sulphur is below** the food grade level. No risks for the catalysts.

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SC CO2 EL GRADO, SLU

I.86.01.01 / Rev:0

Certificado de Análisis CO2

Línea nº:	12	Fecha:	06/09/2024
Batch nº:	8317	Hora:	14:09:33
Nº de LOTE:	24/01/D/000	Nº de albarán:	24/01/A/000
PRECINTOS:	BOTELLA CO2-VIÑAS DEL VERO		

Pureza	Resultados Análisis			Especificaciones		
CO2	>	99.95	%	>	99.99	%
Impurezas	**Resultados Análisis**			**Especificaciones**		
CO		66.55	ppm	≤	10.00	ppm
CH4	<	0.10	ppm	≤	30.00	ppm
THC		124.81	ppm	≤	20.00	ppm
C6H6	<	0.01	ppm	≤	0.02	ppm
C7H8	<	0.01	ppm	≤	0.02	ppm
pm-C8H10	<	0.01	ppm	≤	0.02	ppm
o-C8H10	<	0.01	ppm	≤	0.02	ppm
C2H4O		27.94	ppm	≤	0.20	ppm
CH3OH		2.93	ppm	≤	10.00	ppm
C2H5OH	<	0.10	ppm	≤	1.00	ppm
TS		0.01	ppm	≤	0.10	ppm
O2		96.80	ppm	≤	20.00	ppm
NH3	<	0.20	ppm	≤	2.50	ppm
NO		0.75	ppm	≤	2.50	ppm
NO2		0.80	ppm	≤	2.50	ppm
NOX		1.54	ppm	≤	2.50	ppm
H2O		103.77	ppm	≤	20.00	ppm
Sabor		Característico			Característico	
Olor		Característico			Característico	
Aspecto		Ausencia			Ausencia	
TOTAL	≤	424.70	ppm			

Catalyst tests and first results

Base:

Synthesized Ni-based catalyst (**Ni-based**) – 100-200 µm particles.

Promoted catalysts:

- **Promoter 1 → Ni-Prom1**
- **Promoter 2 → Ni-Prom2**
- **Promoter 3 → Ni-Prom3**

Goal:

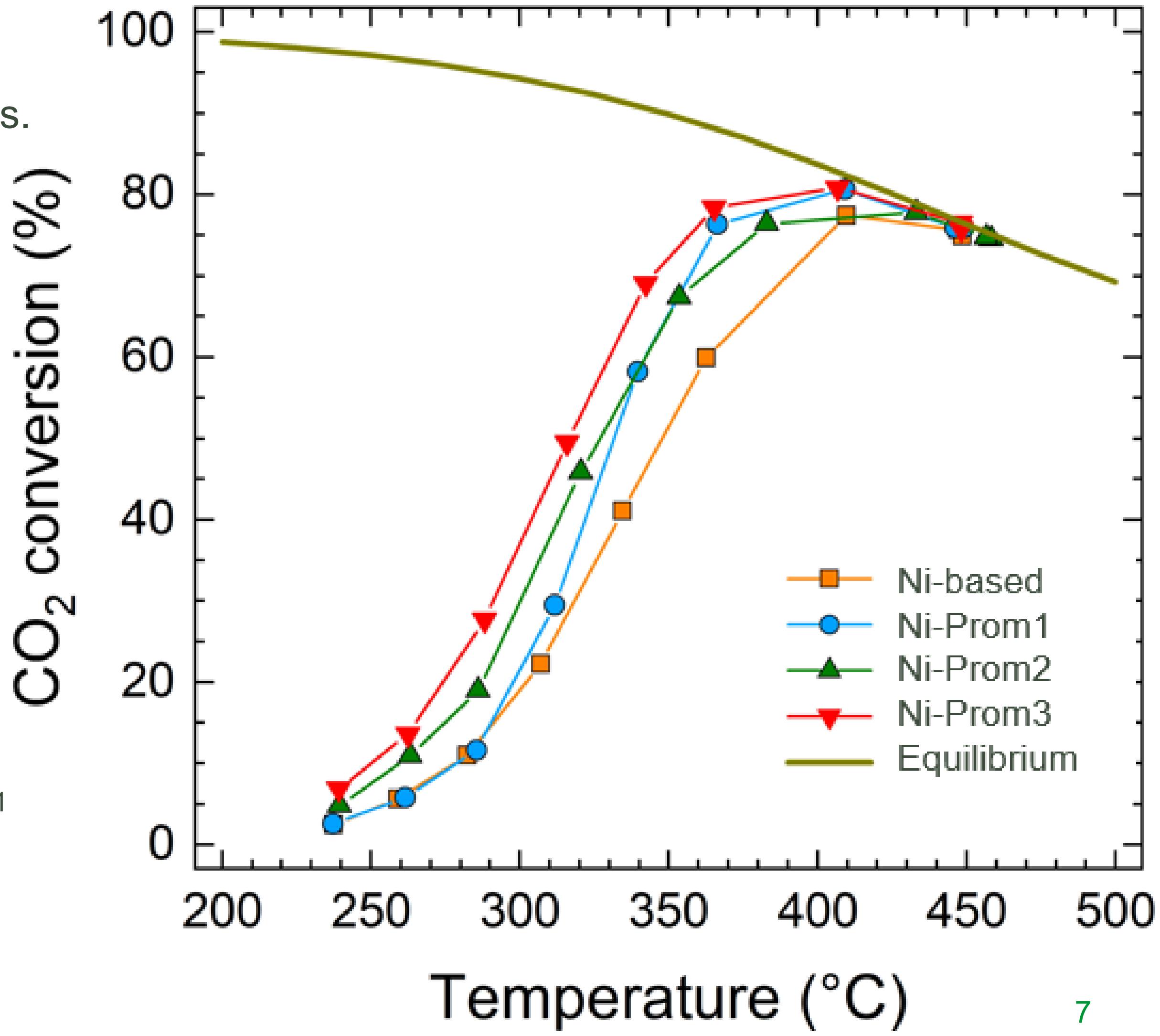
Increase stability and resistance to sintering and coking.

Conditions:

P = 1 atm

$H_2:CO_2$ molar ratio = 4

CO_2 weight hourly space velocity (WHSV) = 0.54 $mol_{CO2} \cdot g_{cat}^{-1} \cdot h^{-1}$



Testing modified NiProm3 catalyst

An additional catalyst was prepared and tested by adding another material as a second promoter to the Ni-Prom3 catalyst (**NiProm3-Modified**).

Conditions:

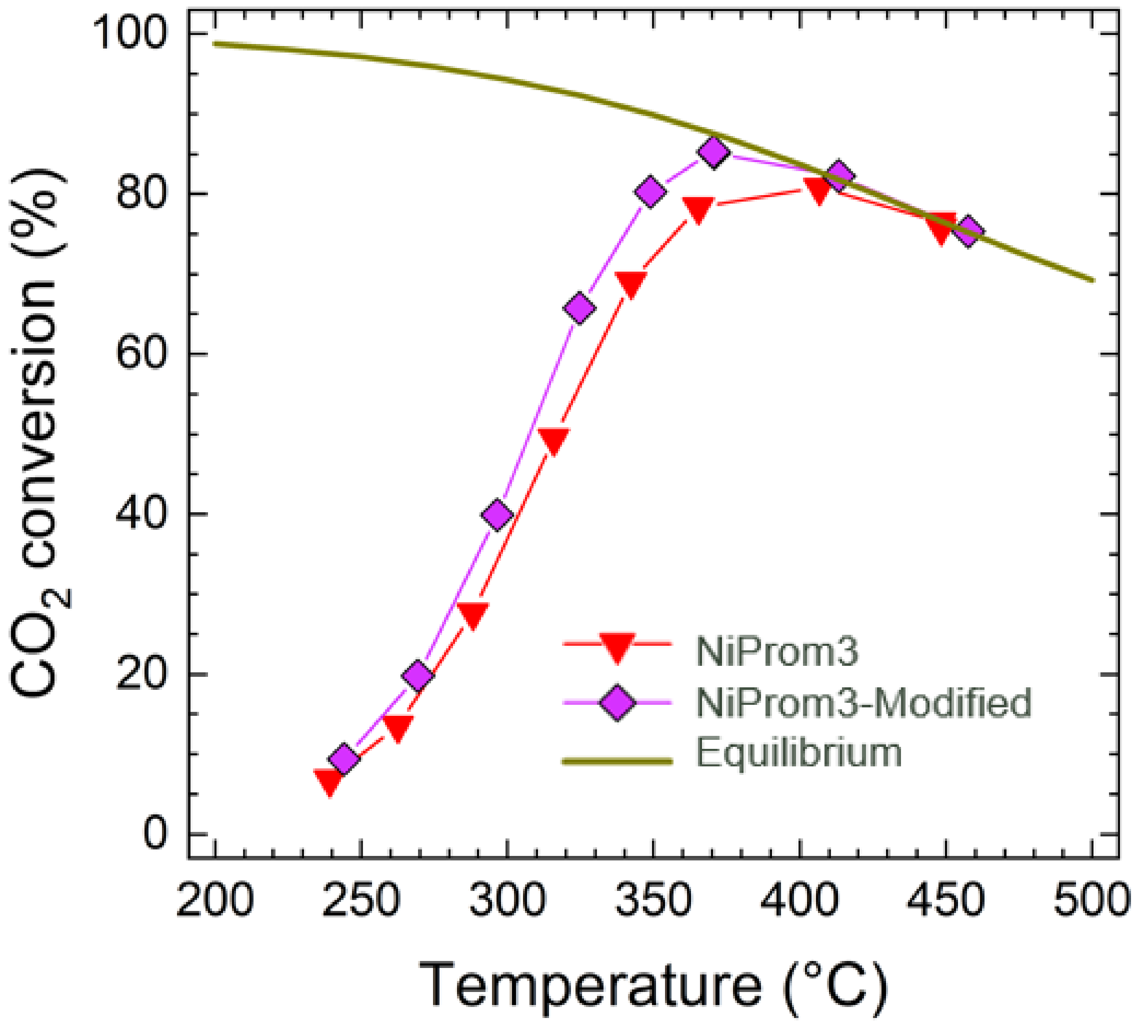
P = 1 atm

H_2:CO_2 molar ratio = 4

WHSV = 0.54 $mol_{CO2} \cdot g_{cat}^{-1} \cdot h^{-1}$

Results

- Slight improvement, mainly above 300 °C.
- No significant advantage and more complex → Not selected.



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Lifetime Test with Real Winery CO_2

Extended evaluation for the **NiProm3** for matching real reaction conditions.

Conditions:

P = 1 atm

T = 300 °C

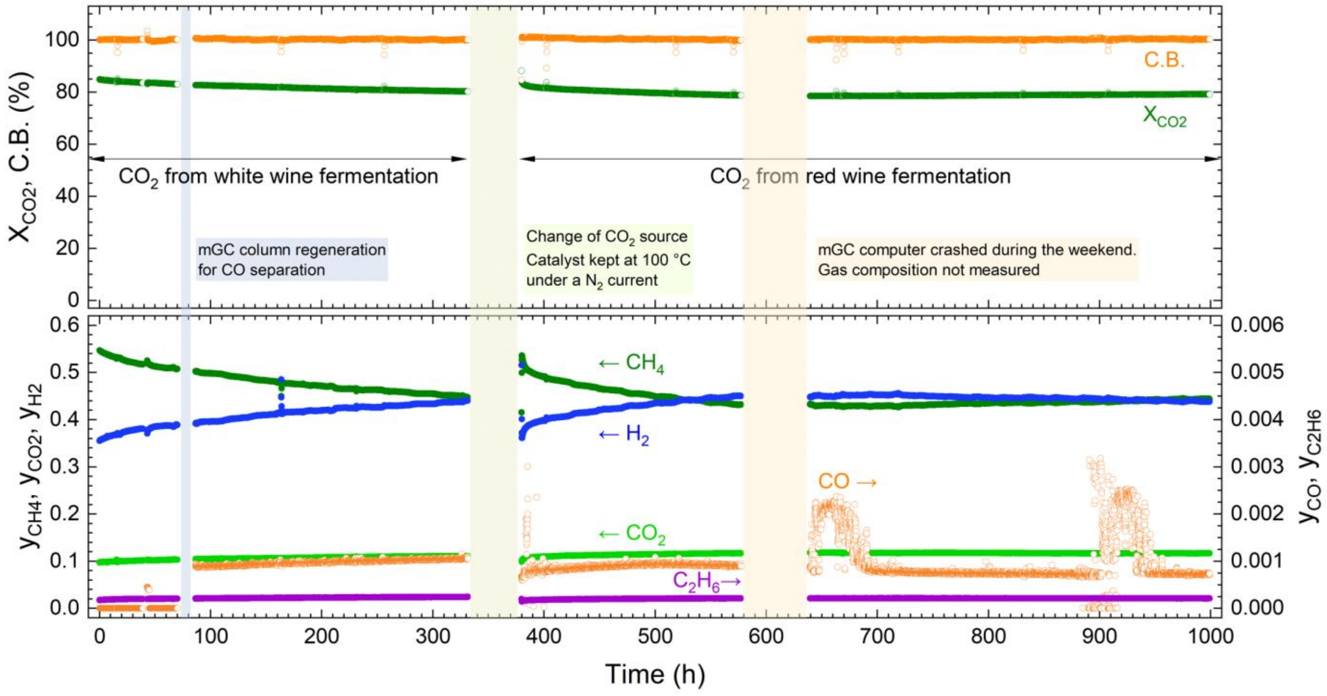
H_2:CO_2 molar ratio = 4

WHSV = 0.18 $mol_{CO2} \cdot g_{cat}^{-1} \cdot h^{-1}$

Feed = CO_2 from white and red wine fermentation.

Results:

- Initial conversion ≈ 85 %, stabilized at 80 % after 250 h.
- Total time on stream = 1000 h (≈ 41 days)
- High stability and CH_4 selectivity.
- Performance was similar when switching from white to red wine CO_2, demonstrating robustness to feedstock variations.



NiProm3 confirmed as DEMO 2 catalyst

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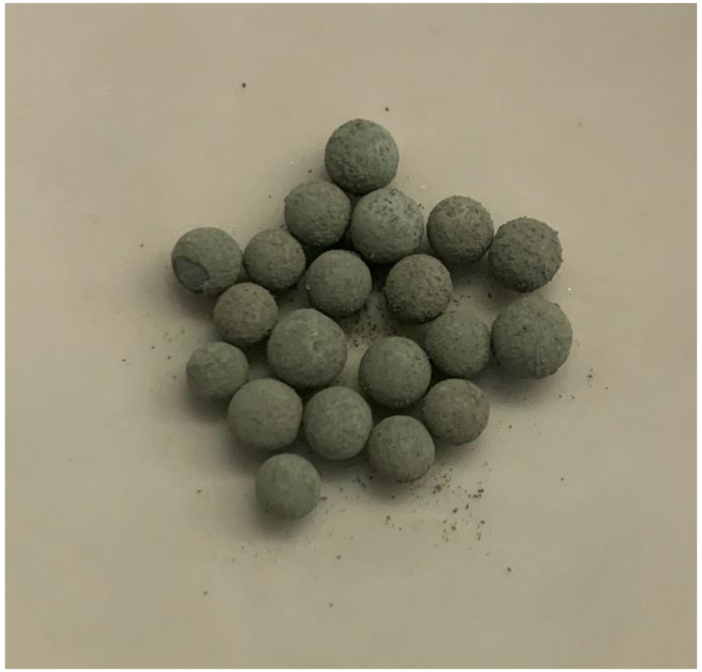
From Powder to Reactor Pellets

Coprecipitation method produces fine powder (<1 mm) → Unsuitable for fixed-bed reactor.

Two routes explored to increase particle size:

1. Impregnation on commercial particles



2. Pelletization by cold pressing the NiProm3 precursor

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Impregnation on commercial particles

Two samples were synthesized:

- **Ni-based-pellet**
- **NiProm3-pellet**

Conditions:

P = 1 atm

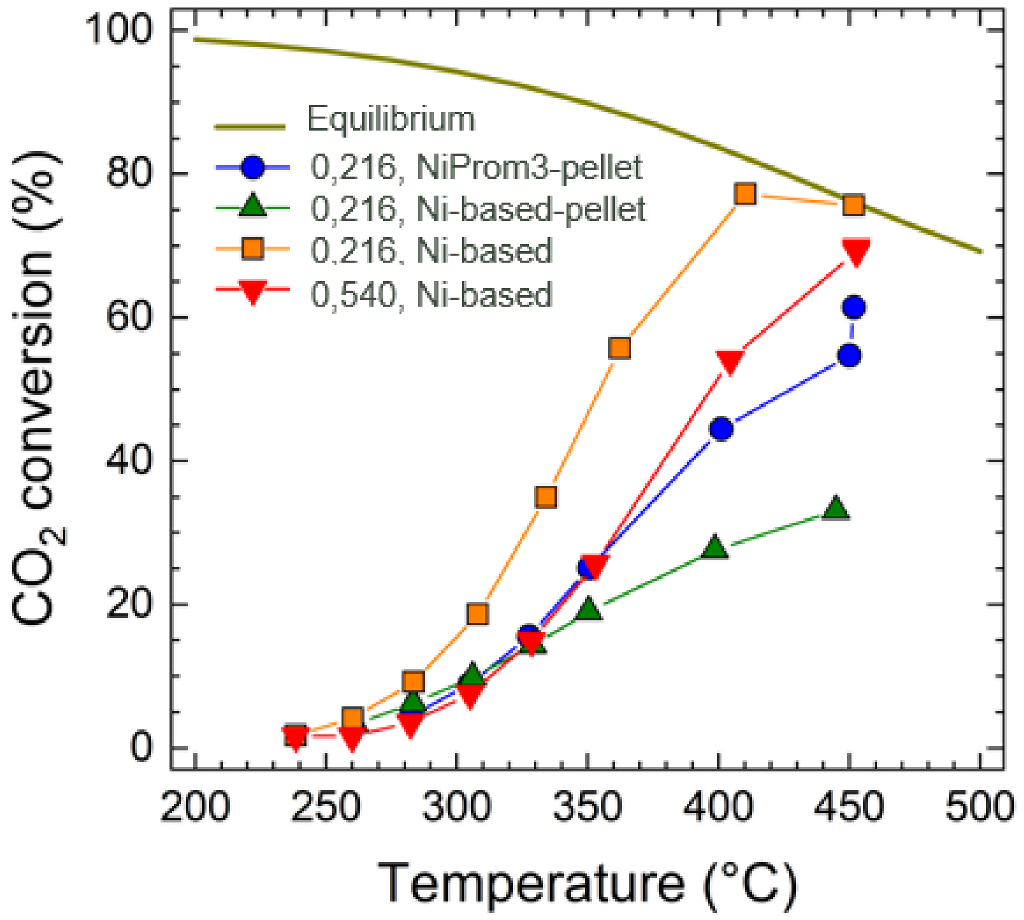
H_2:CO_2 molar ratio = 4

WHSV = 0.216 $mol_{CO2} \cdot g_{cat}^{-1} \cdot h^{-1}$

Results:

- Large particles (1/8") limited by diffusion → Lower conversion.
- The **NiProm3-pellet** catalyst showed deactivation above 400 °C.

This is not the optimal solution for the DEMO reactor.



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Pelletized Catalyst Performance

Pellets of cold **NiProm3**: cylindrical 3 mm × 2.5 mm.

Good mechanical integrity after calcination.

Conditions:

P = 1 atm

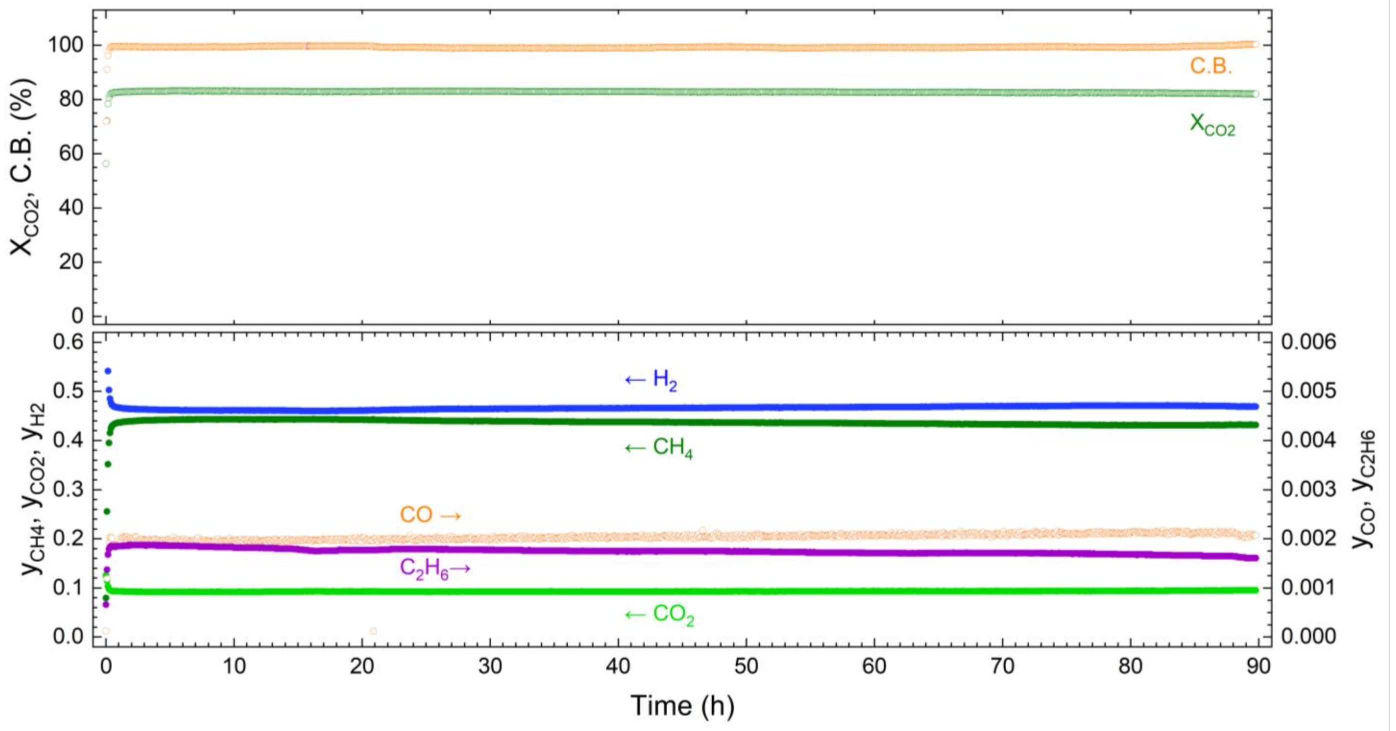
T = 360 ºC

H_2:CO_2 molar ratio = 4

WHSV = 0.027 $mol_{CO2}·g_{cat}^{-1}·h^{-1}$

Results:

- 82 % conversion, stable after 90 h (almost 4 days).
- High CH_4 selectivity → Suitable for DEMO 2 reactor.



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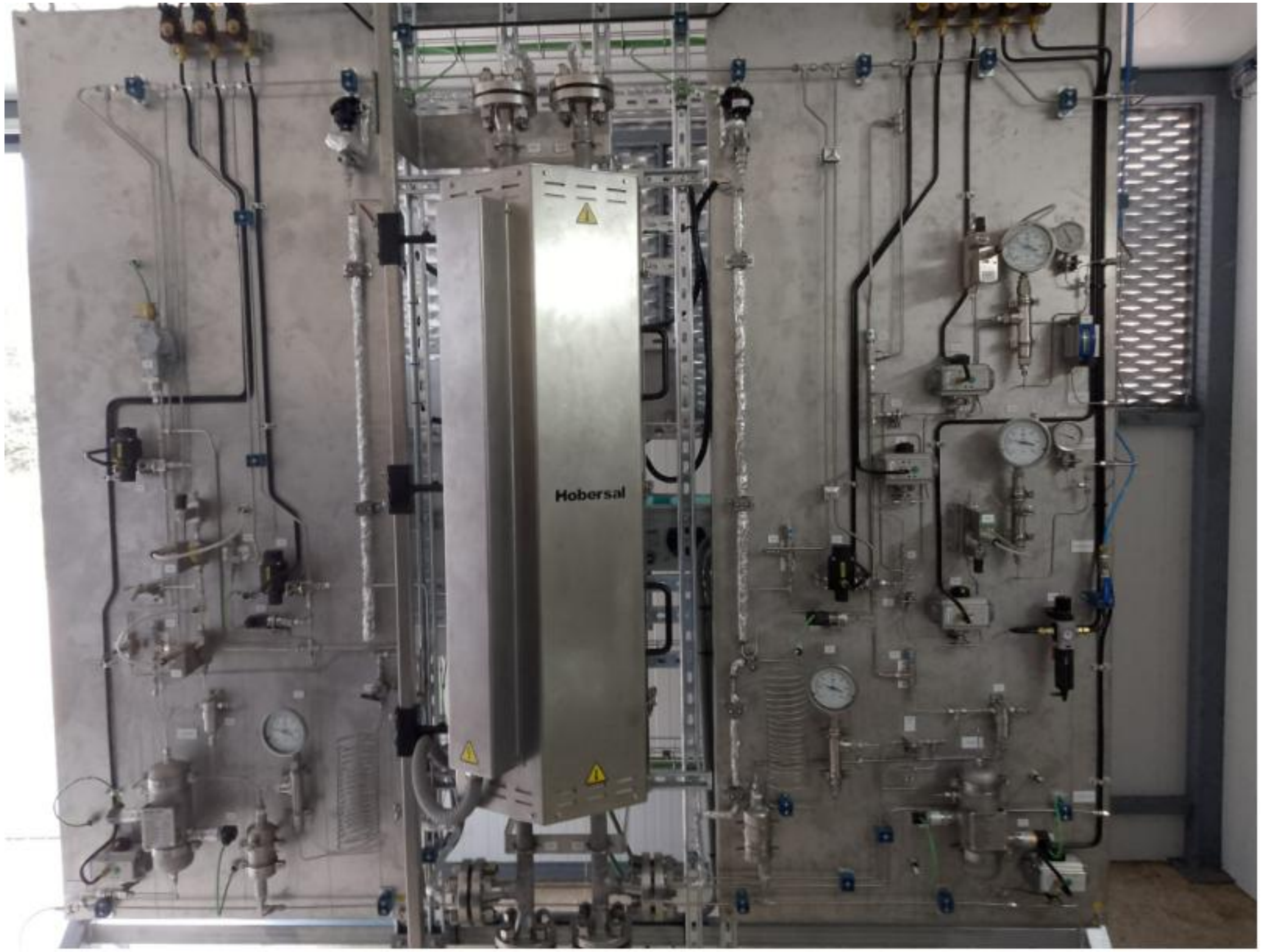
Methanation unit - Overview

Reactor prototype commissioned for DEMO 2

- Leak-tightness of the full line successfully verified
- Catalyst activation performed during the initial heat-up phase
- System start-up completed under controlled pressure and temperature
- First temperature and conversion profiles obtained using real winery CO_2



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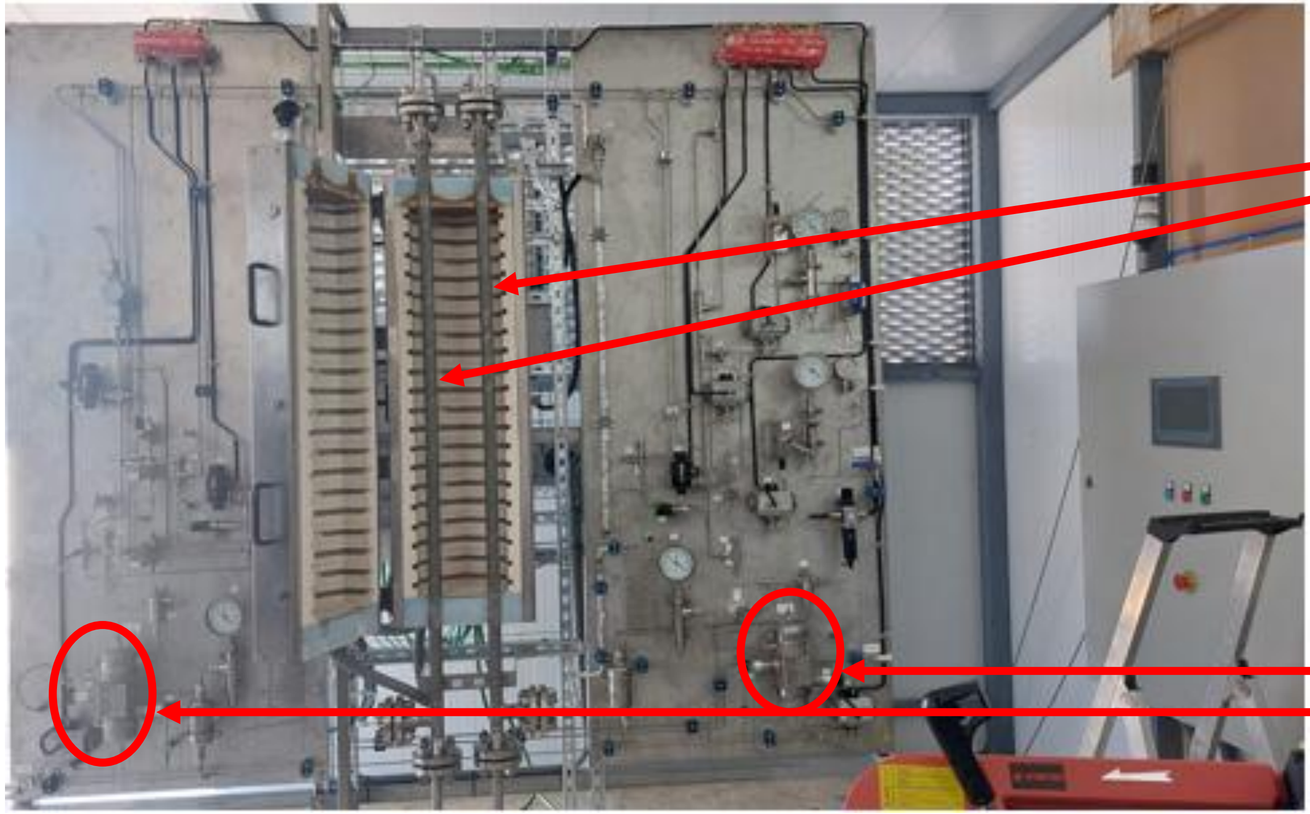
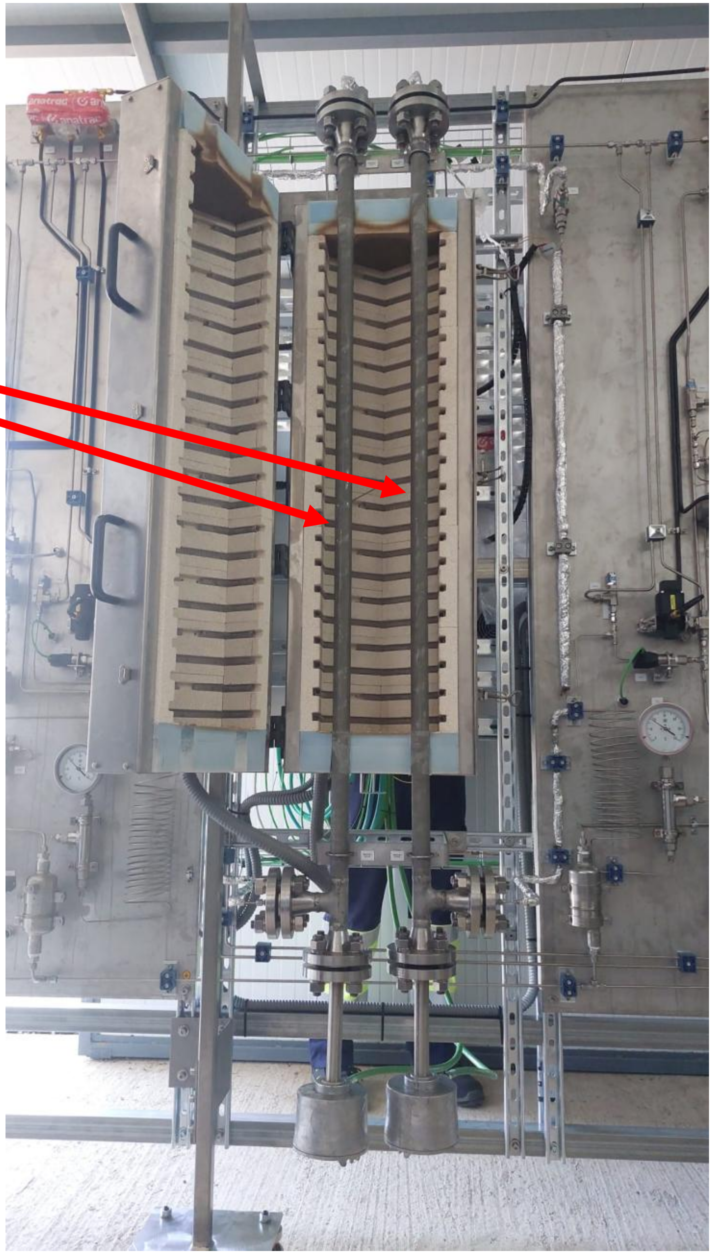
Methanation unit - Overview





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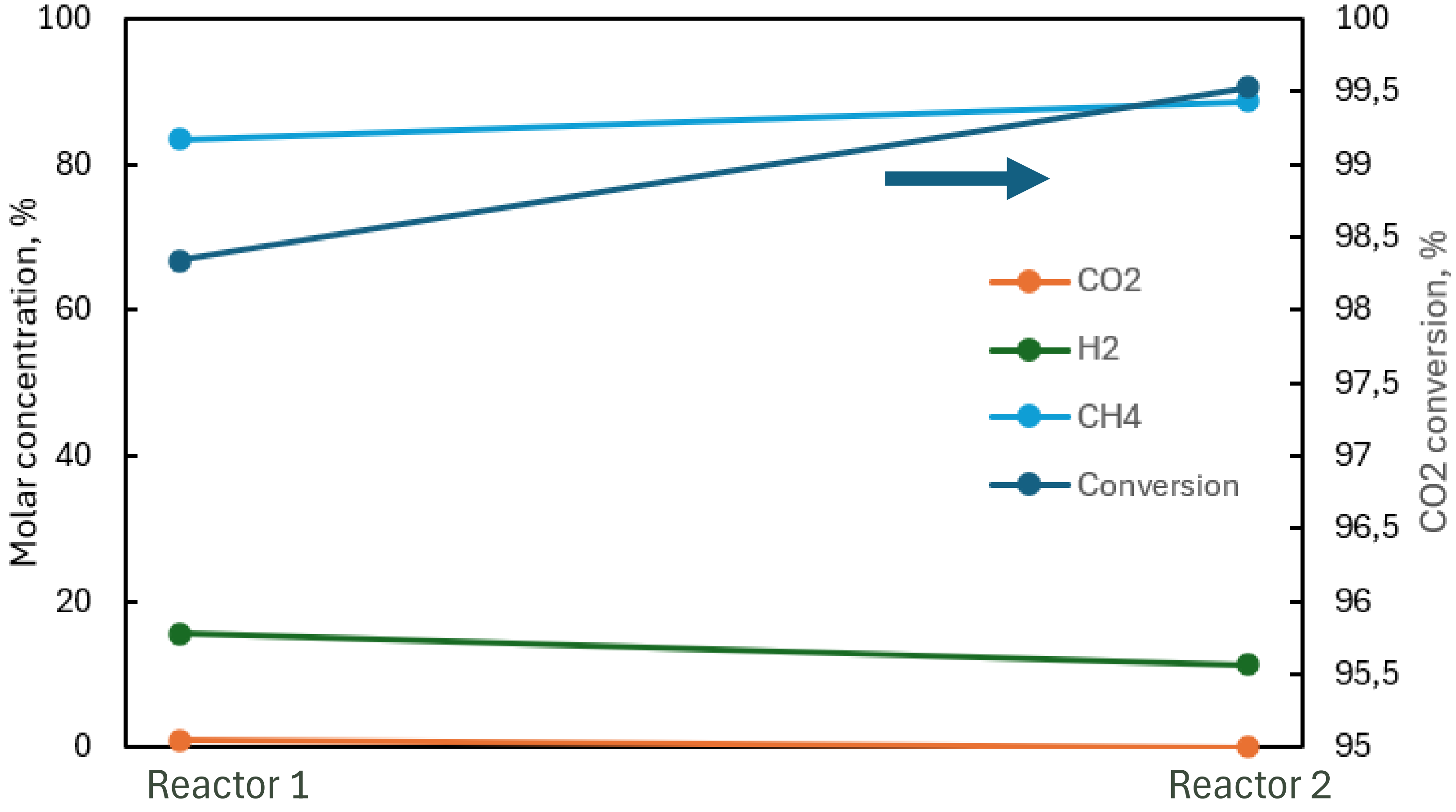
First test during start-up

Conditions

Feed
H_2 flowrate = 0.027 kg/h
CO_2 flowrate = 0.130 kg/h
H_2/CO_2 = 4.57

Temperature
$T_{Furnace}$ = 200 ºC

Pressure
P = 7 bar



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Next steps and improvements

- The demo aims to perform long-term lifetime tests of the catalyst under industrial conditions. The system will operate with a stoichiometric CO_2/H_2 feed, maintaining temperatures below 500 °C and working pressures between 5 and 10 bar.

- Further optimization of the reactor thermal control to ensure a more uniform temperature distribution during long-term operation.

- Validation of the numerical reactor model by comparing predicted and measured temperature and composition profiles in upcoming test campaigns.

About FUELPHORIA

FUELPHORIA is an EU-funded Innovation Action project working to establish sustainable, competitive, and secure value chains for advanced biofuels and renewable fuels of non-biological origin.

Coordinated by CERTH, the project will set up and test a portfolio of 9 complete value chains in Belgium, Greece, and Spain.

Project partners will also evaluate the environmental performance of the FUELPHORIA renewable fuels, design innovative business models to prepare their market entry, and explore their export potential through collaboration with Africa

Get in touch

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