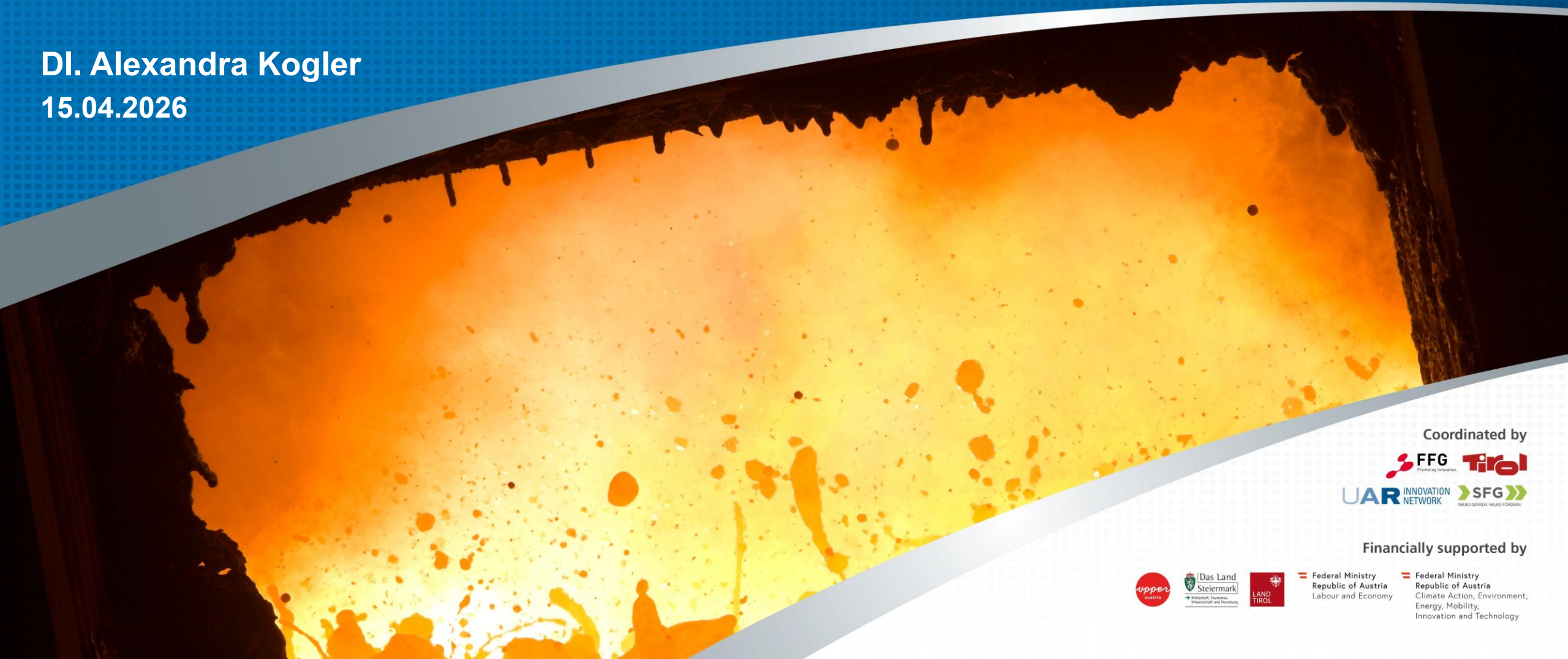
Closing the carbon loop - amine scrubbing and catalytic methanation at an integrated steel-mill

DI. Alexandra Kogler

15.04.2026



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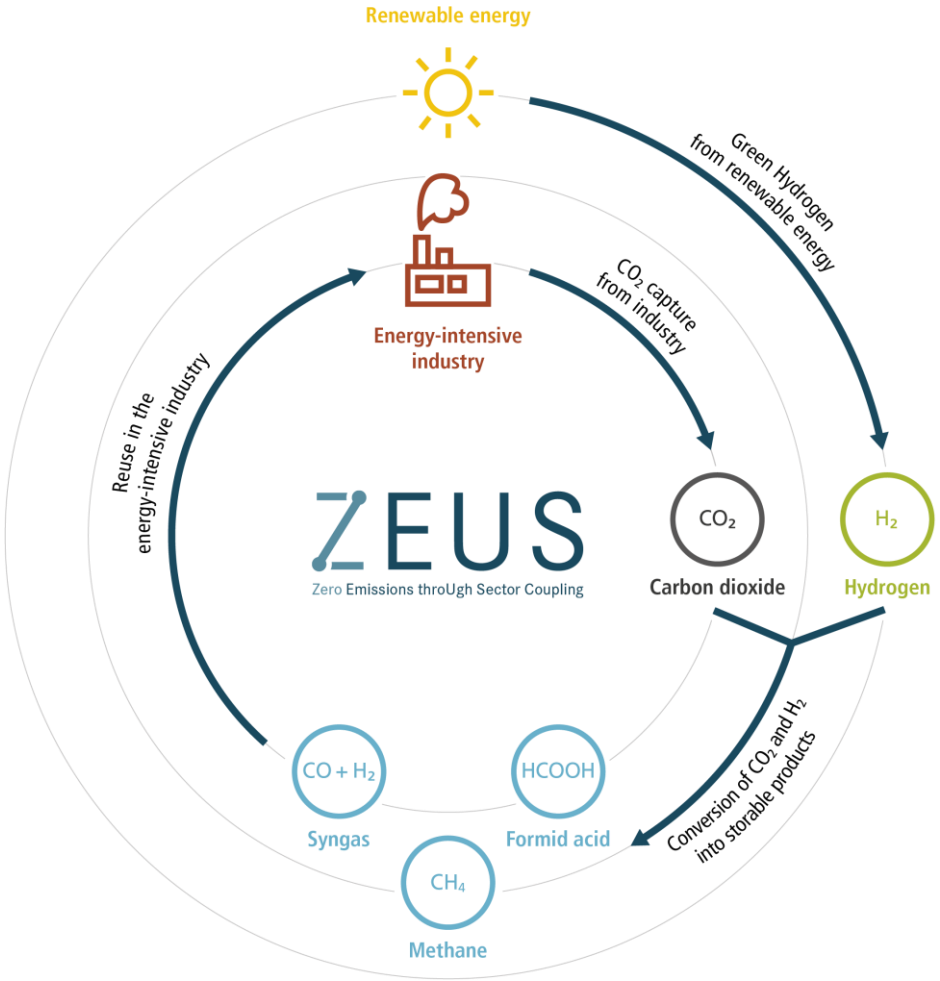
ZEUS project



Project goals

- Cross-sectoral demonstration of a **climate-neutral process chain** under real / dynamic conditions (**TRL > 6**)
- Accelerate the **technology transfer** into practice
- **Techno-economic assessment** (CO_2 electrolysis costs vs. CO_2-emission certificates)

Project costs: 16.7 M€
Funding: Climate and Energy Fund FFG

Carbon capture via amine scrubber pilot plant

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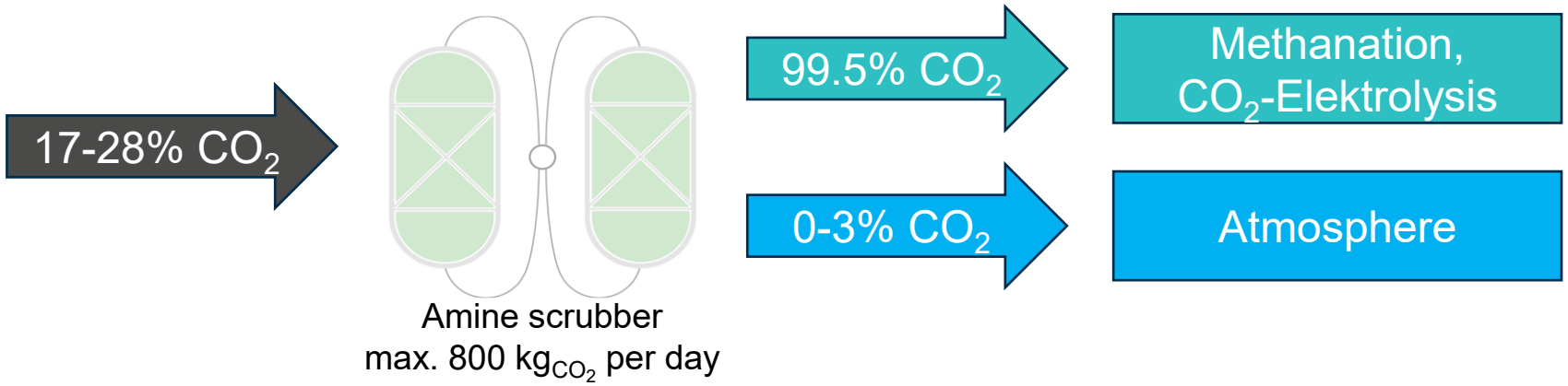
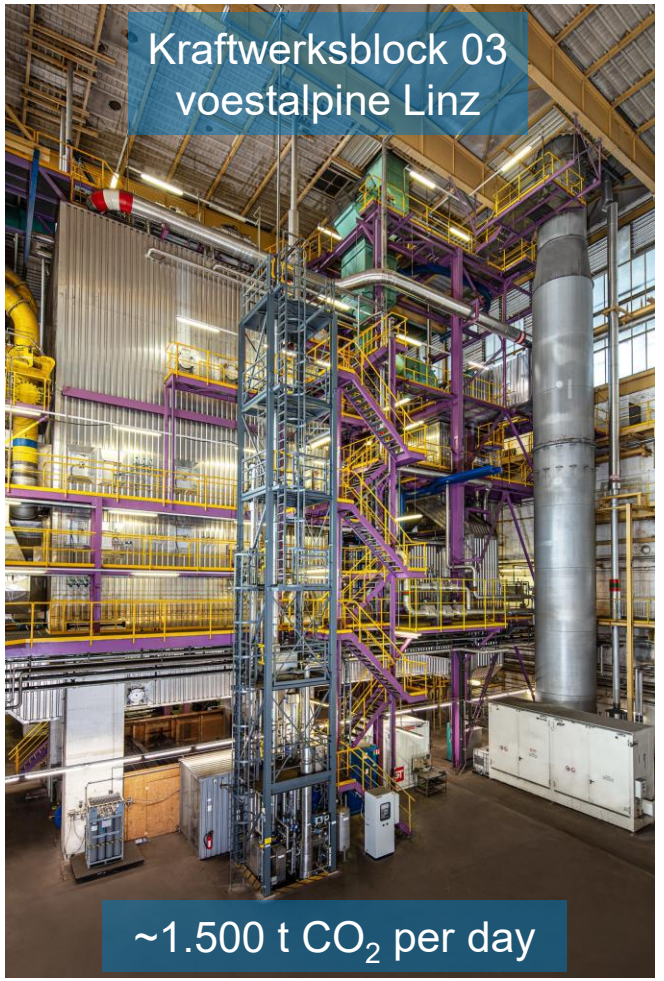
- Demonstration and further development of amine scrubbing technology using exhaust gases from the steel industry

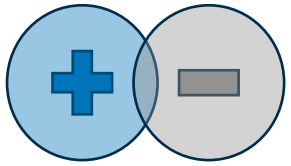




Purity productgas >99.5% CO_2

Capture efficiency >90%

TRL = 9



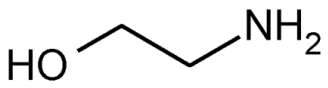
Energy demand 3-4 GJ/t_{CO_2}

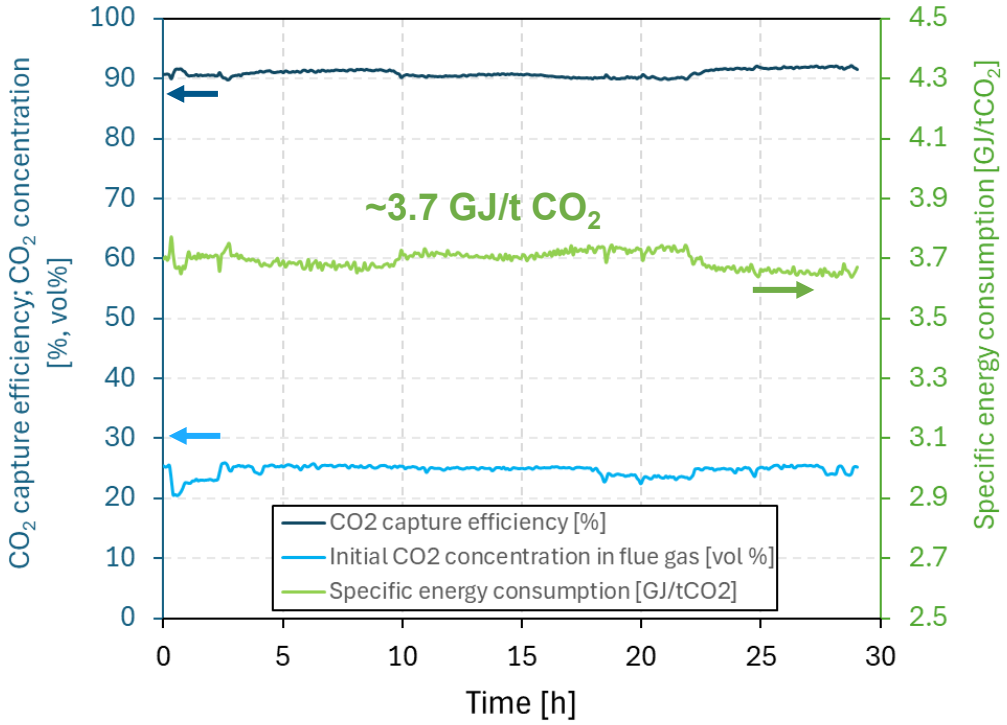
Solvent loss

Emissions

Influence of amine solvent composition on energy consumption (30h experiment)

Benchmark solution:
Monoethanolamine (MEA)

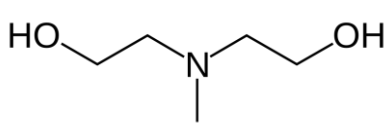




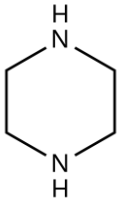
Gas composition: CO_2 99.5%, O_2 43ppm, N_2 300ppm, Rest H_2O

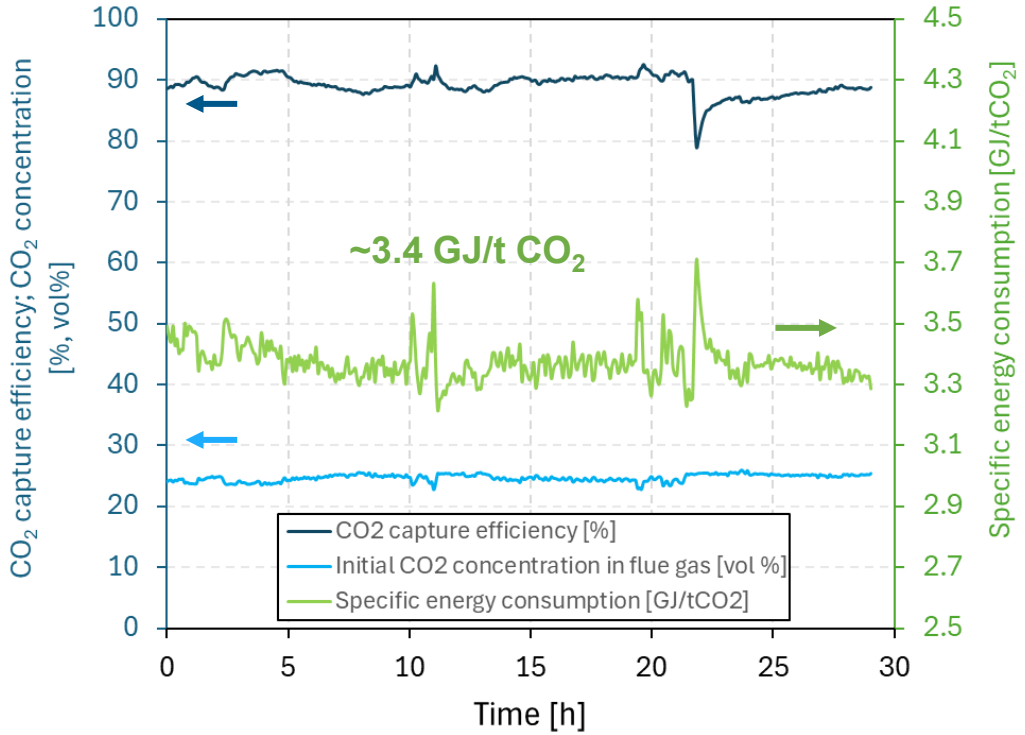
MDEA

Activated monodiethanolamine (aMDEA)



+ Piperazine





Gas composition: CO_2 99.8%, O_2 <10ppm, N_2 390ppm, Rest H_2O

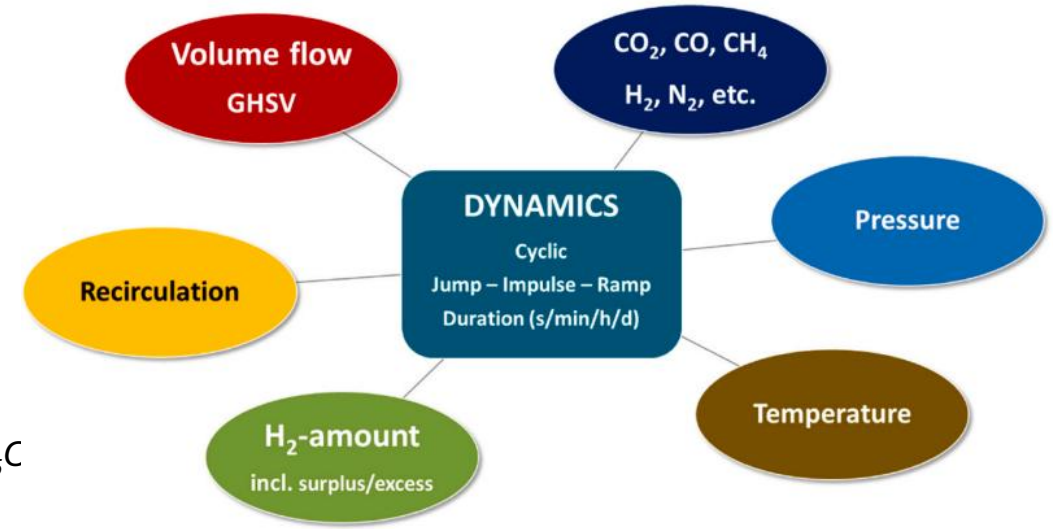
Research objectives methanation

- Long-term operation under dynamic load profiles of H_2 supply (6MW PEM) using innovative bundle reactor concept

→ Chemical storage of electricity

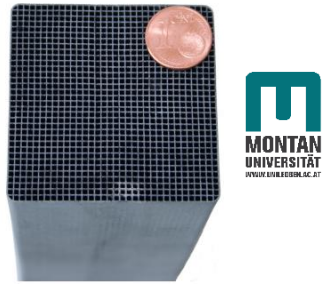
- Evaluation of the durability of nickel-based honeycomb catalysts using CO_2 captured from real flue gas with different impurities (ppm)

Process parameters

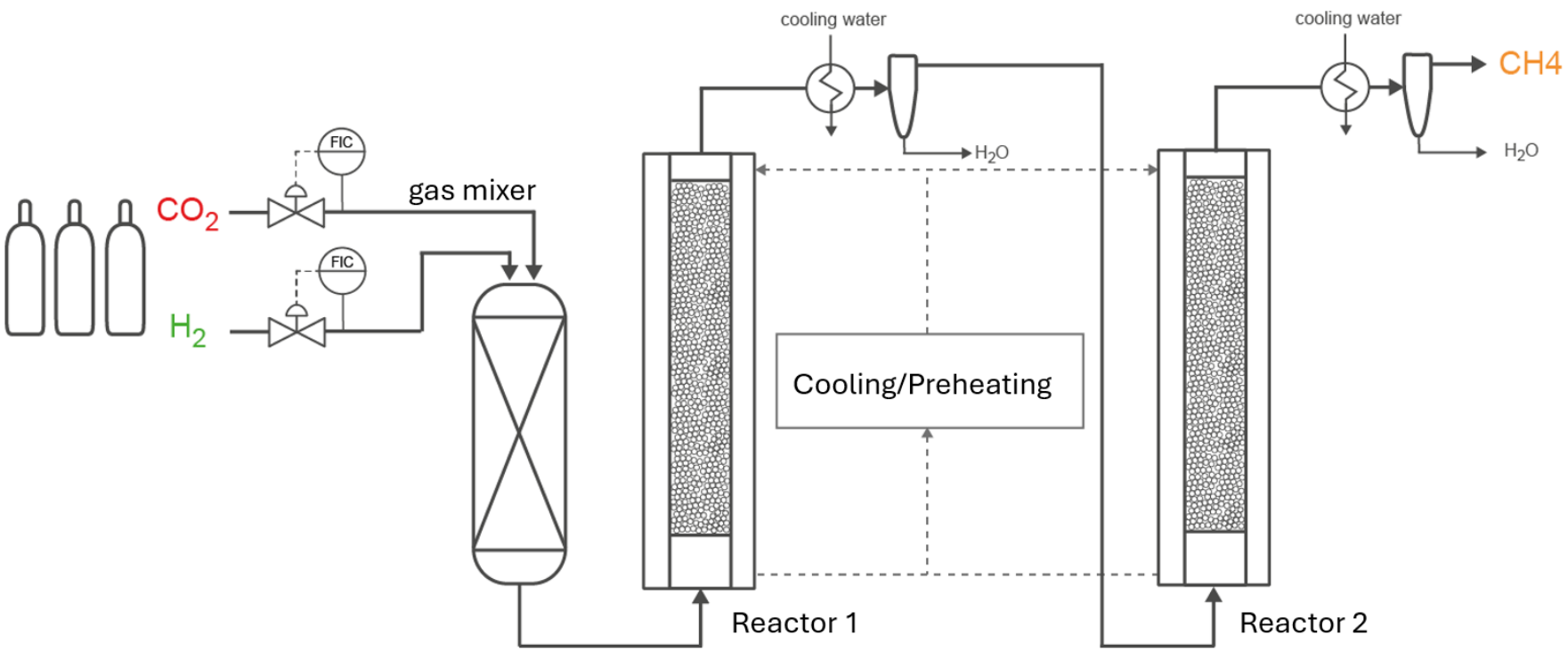


Commercial Catalyst
NiO on Al2O3
3-6mm spheres

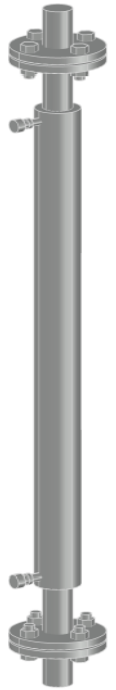
Ni-based honeycomb catalyst
Ni/Al_2O_3 coated on cordierite $Mg_2Al_3[AlSi_5C$

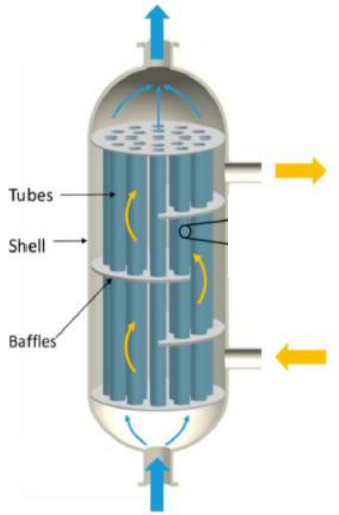


Overview 20kW methanation pilot plant



bundle reactor





Upscale to 100kW methanation plant

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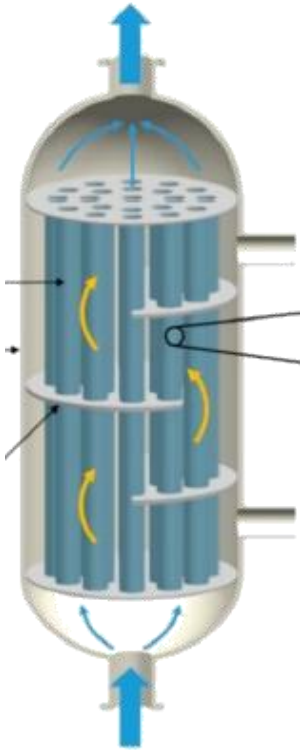
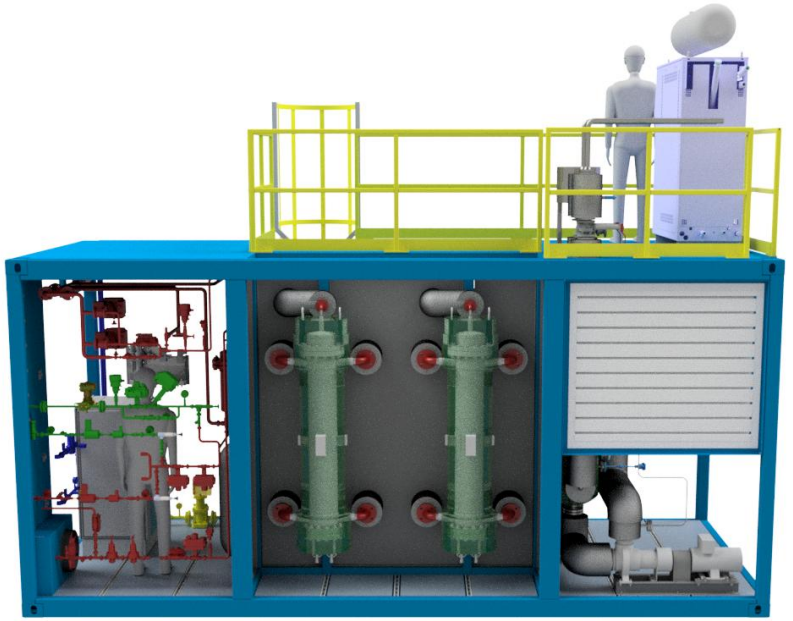
<u>Upscale of pilotplant</u>:

- **Upscale** of existing pilot plant to 100 kWSNG (~ 10 Nm³/h SNG)
- **Digital modeling** of the CCU process chain
  → Flowsheet simulation in ASPEN Plus®





Benchmark with commerical catalyst and CO_2 from amine scrubber: Influence of process parameters

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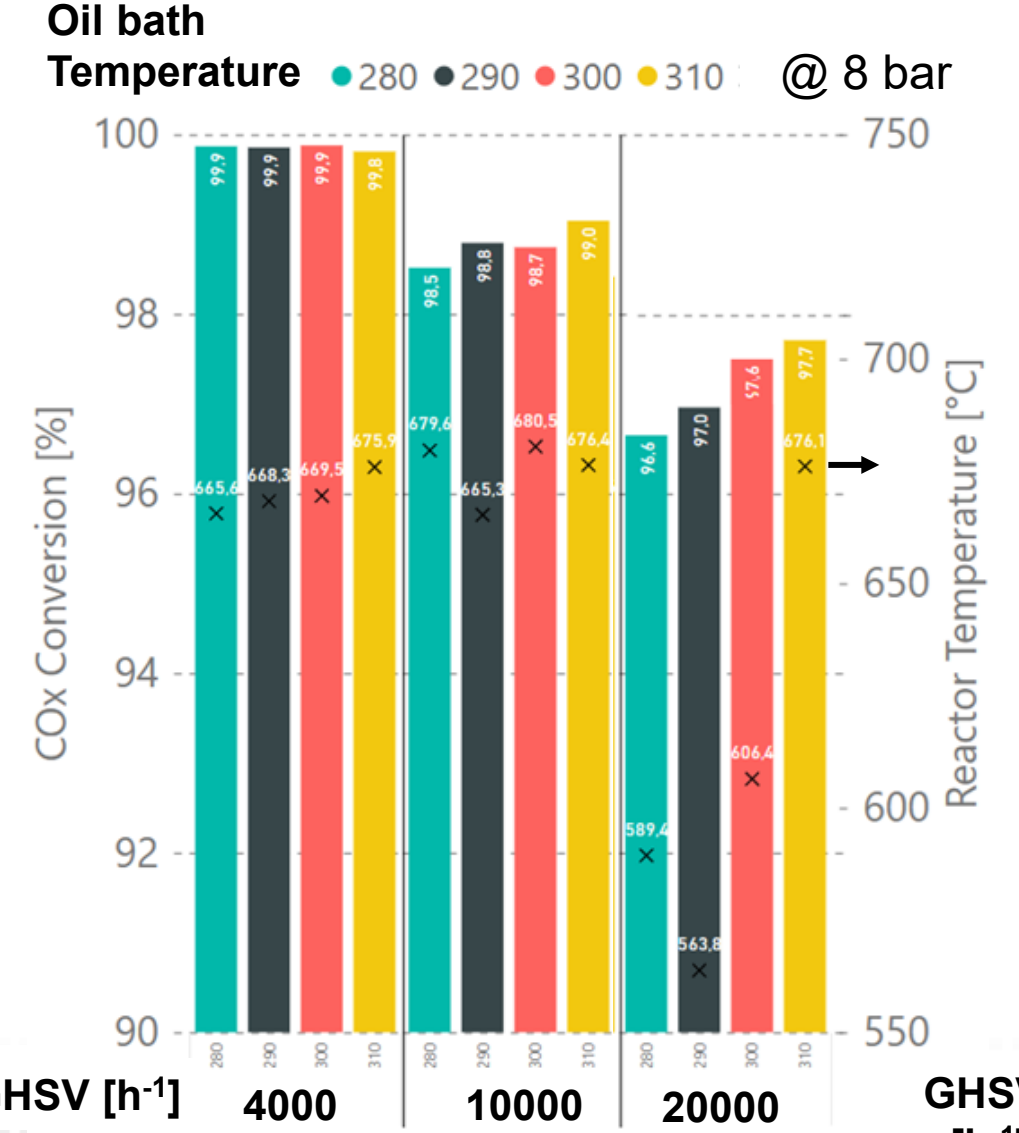
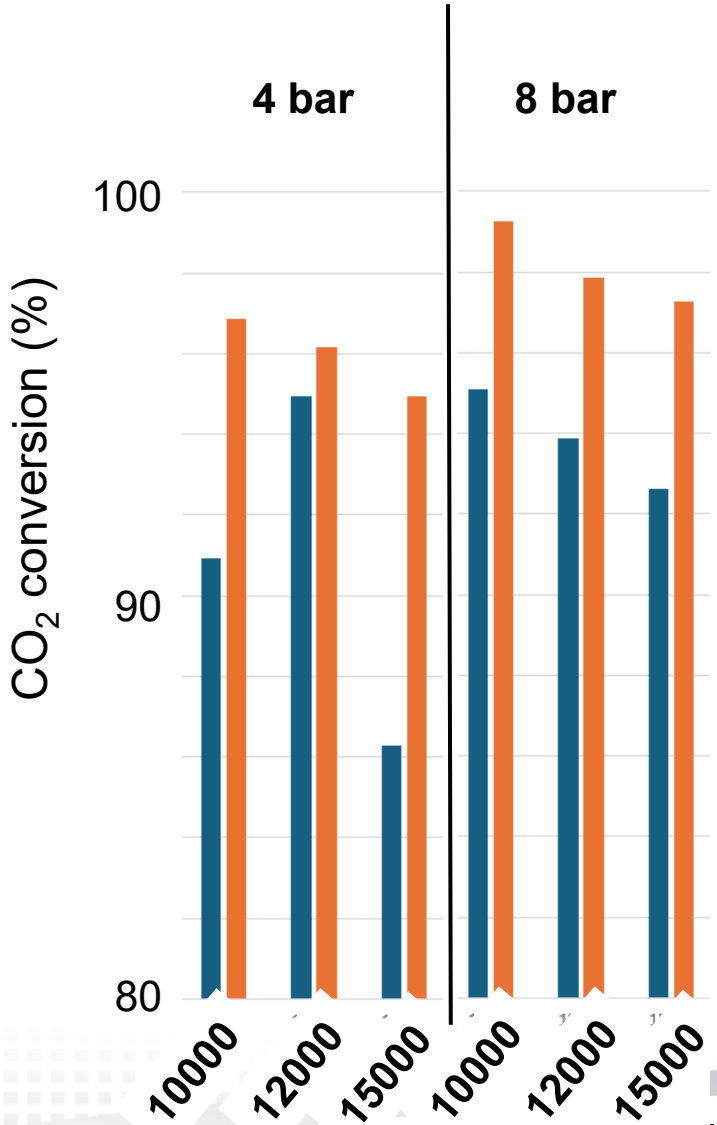




Screening parameters:

- p = 4-12 bar
- T = 250-320°C
- GHSV (gas hourly space velocity) = 4000 - 20000 h^{-1}
- H_2-surplus = 1-4%

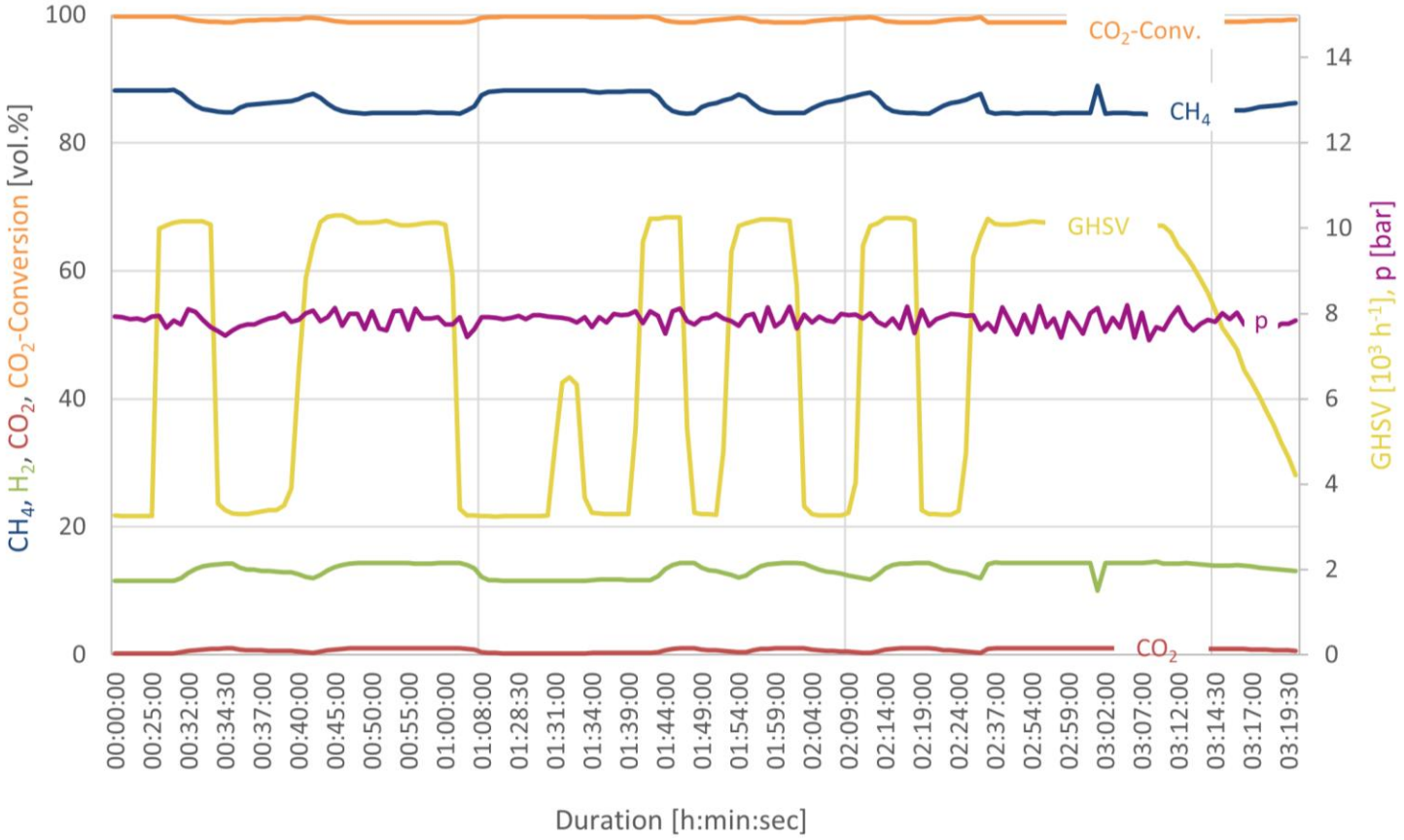
$$GHSV = \frac{\dot{V}^0}{V_{Kat}}$$

Reactor volume 1L: 10000h^{-1} = 10m^3/h is processed

Oil bath Temperature

- 250°C
- 310°C

Dynamic methanation 20 kW_{SNG}



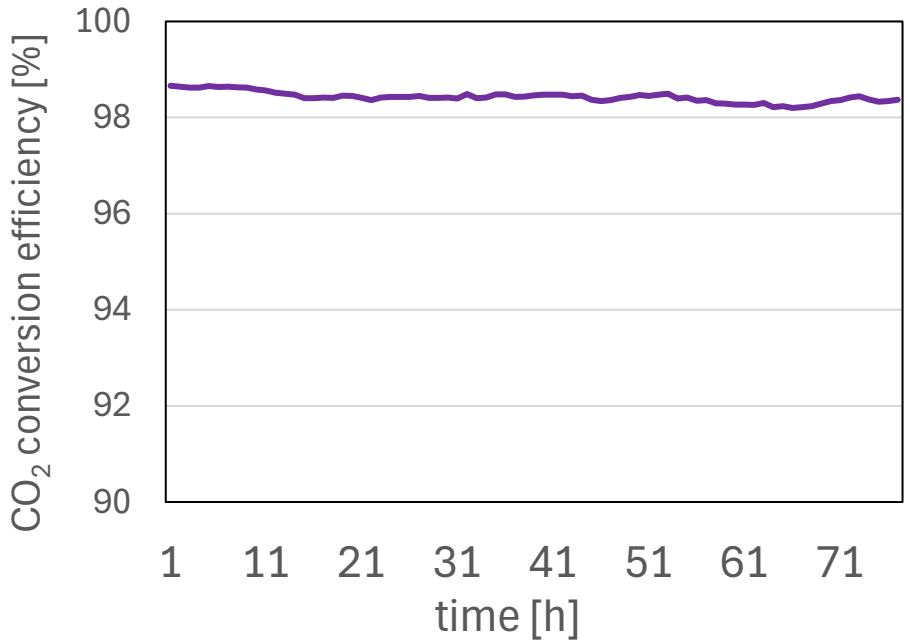
- Load-flexible scenario based on data from PEM electrolysis → variable GHSV (gas hourly space velocity)
- Constant turnover close to target of 100%

- T_{cool} = 310 °C
- P = 8 bar_g
- 1 reaction stage

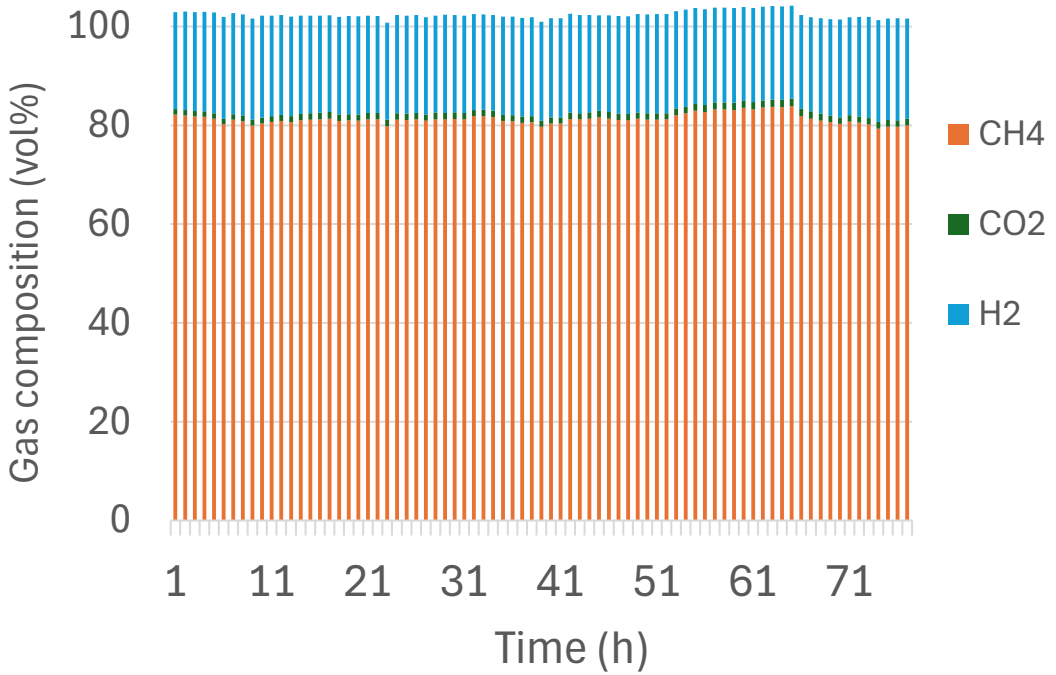
- Real gases CO_2 & H_2
- 3% H_2 surplus
- Meth134

Continous Methanation over 76h

CO_2 conversion efficiency
>98% over 76h



Stable Gas composition over 76h
Methanation



Process conditions:

p = 8 bar, T = 310°C, GHSV = 10000 h^{-1}, H_2-surplus = 3%

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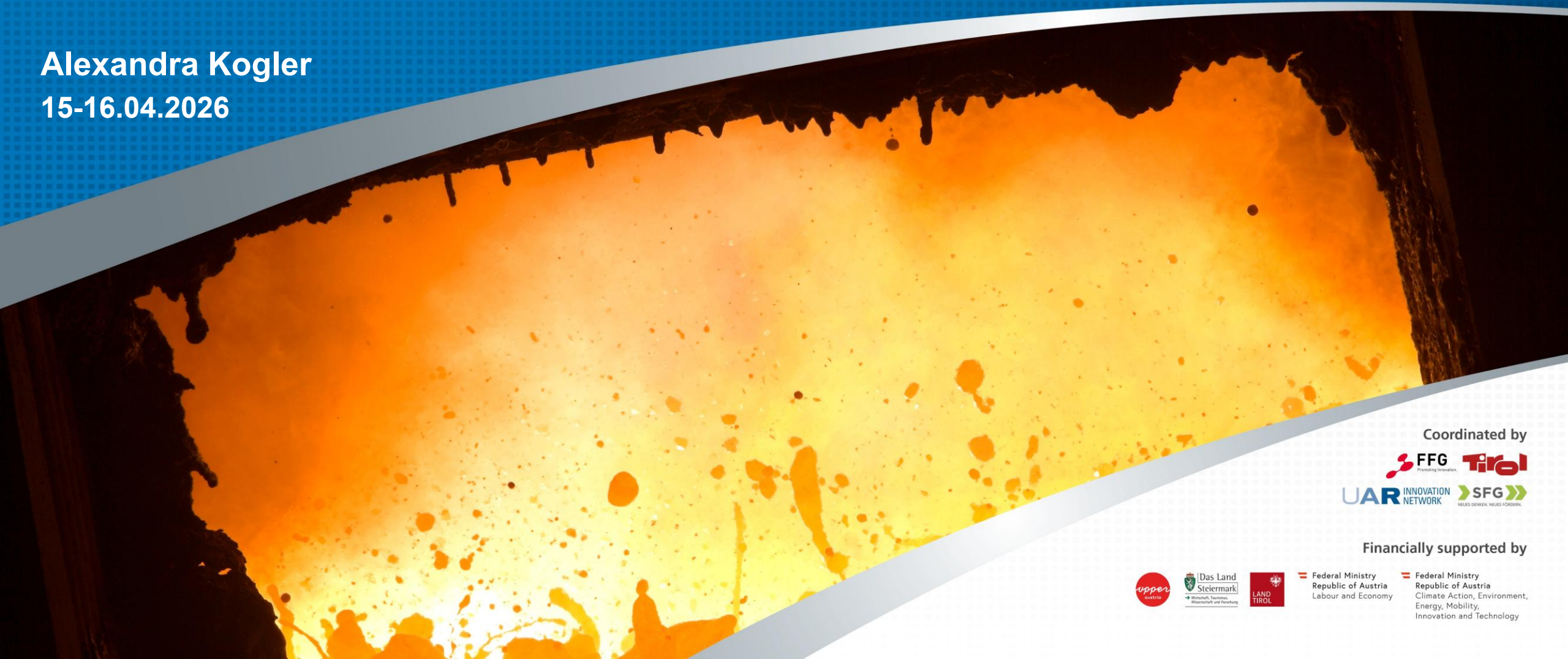

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