



Technologieentwicklungen zur Methanisierung

## ExpertInnen-Gespräche Power-to-X

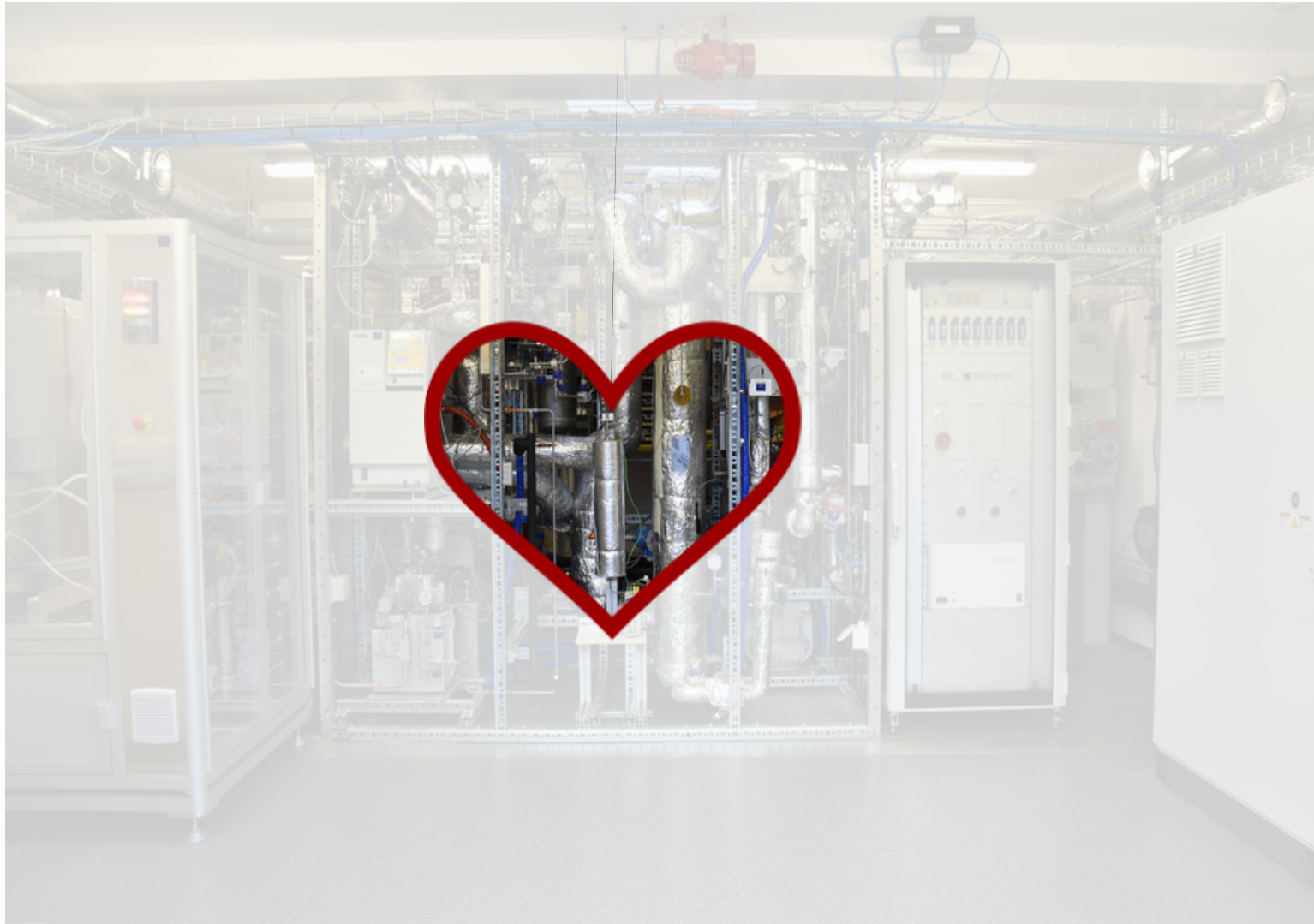
23.09.2021

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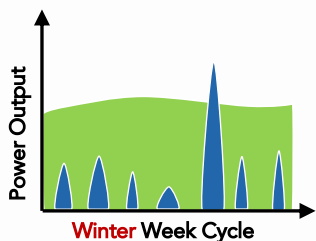
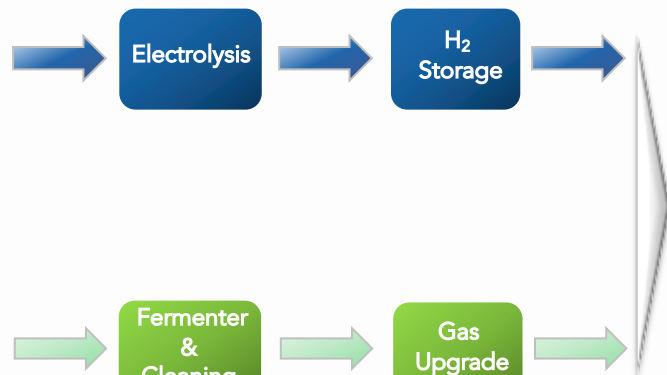
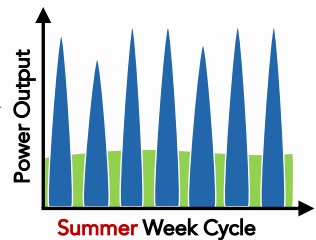
Advanced Materials & Processes

# HEPP – High Efficiency Power to Gas Plant Demonstrator



Images from IET at OST (<https://www.iet.hsr.ch>)

# The Solution: «Defossilisation» Renewable Energy Carriers & Power-to-Gas



## Technical & energetic restrictions

- H<sub>2</sub> is limited on 2 (10) vol% (CH) → turbines & car engines
- Biogas purity: CO<sub>2</sub> & H<sub>2</sub>S → Catalysts



Storage in existing infrastructure and grids

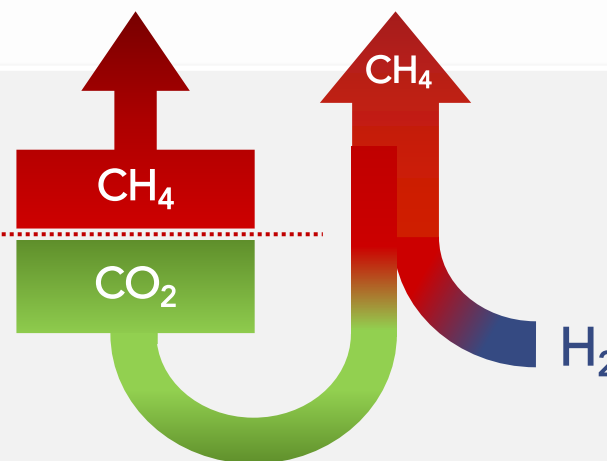


Biological Sources

CH<sub>4</sub> → 50 %

CO<sub>2</sub> → 50 %

+ contaminations



Power-to-Gas

60% CO<sub>2</sub>  
40% CH<sub>4</sub>  
<5% N<sub>2</sub>



25% CO<sub>2</sub>  
70% N<sub>2</sub>



60% CO<sub>2</sub>  
40% N<sub>2</sub>



40% CO<sub>2</sub>  
60% N<sub>2</sub>



10% CO<sub>2</sub>  
50% N<sub>2</sub>  
20% CO



with H<sub>2</sub>O, O<sub>2</sub>, NO<sub>x</sub> it sums up to 100%

Baier, Schneider, Heel, (2018) A Cost Estimation for CO<sub>2</sub> Reduction and Reuse by Methanation from Cement Industry Sources in Switzerland. Front. Energy Res. 6:5. doi: 10.3389/fenrg.2018.00005



Smart Material Approach

**SmartCat**

Lifetime ↗ & Efficiency ↗



Conventional engineering approach

Additional plants for separation, purification, etc.

# SmartCat: Lifetime & Degradation

## Catalytic active phase

- e.g. Ni, Pt, Pd, Ru, Co, Fe, etc.
  - Ni is a **good** methanation catalyst
  - Ni is **highly selective** towards CH<sub>4</sub>
  - Ni is **reasonably cheap**...
  - Ni is **sensitive** to Sulfur

## Catalyst support

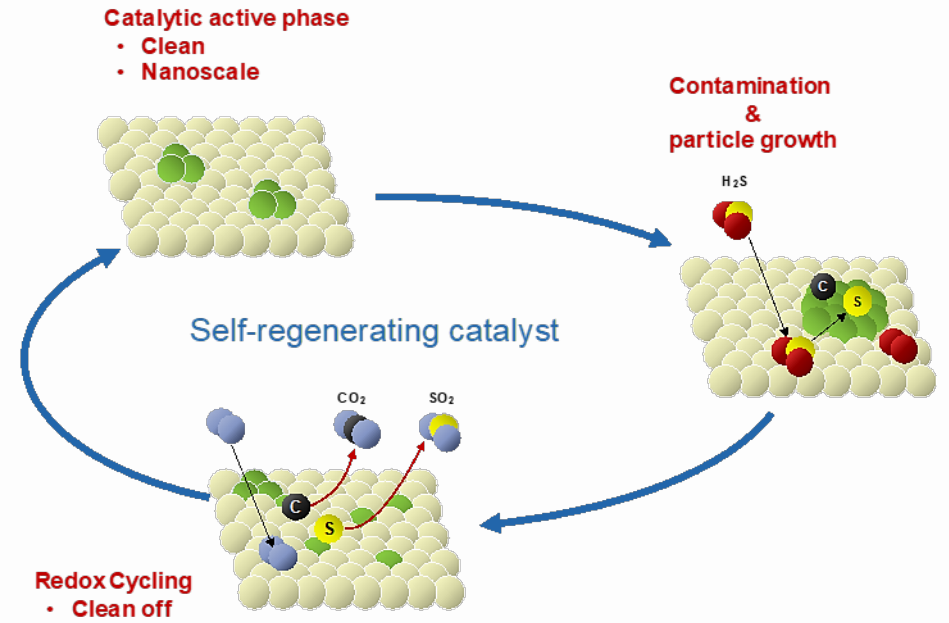
- functional material → Al<sub>2</sub>O<sub>3</sub>



- SMART** material

- Al<sub>58</sub>Si<sub>134</sub>O<sub>384</sub>
- ABO<sub>3-δ</sub>

Zeolite  
Perovskite

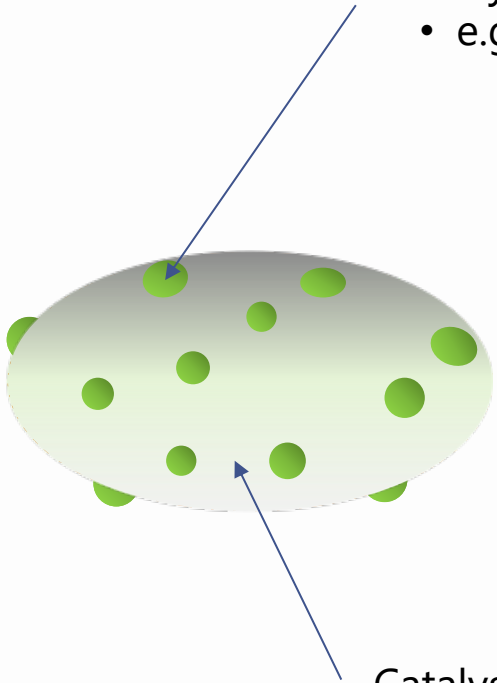


SmartCat II → Sorption Enhanced  
SmartCat I → Self-Regeneration

# SmartCat: Performance & Efficiency

## Catalytic active phase

- e.g. Ni, Pt, Pd, Ru, Co, Fe, etc.
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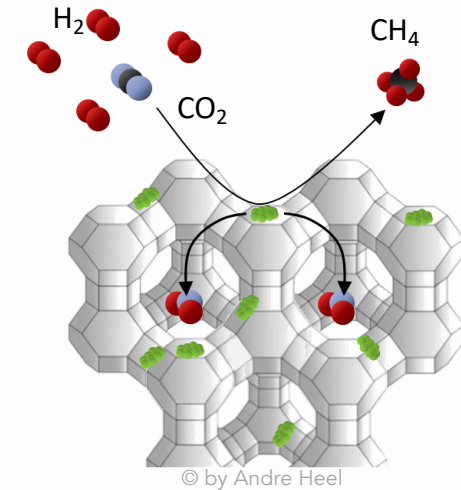


## Catalyst support

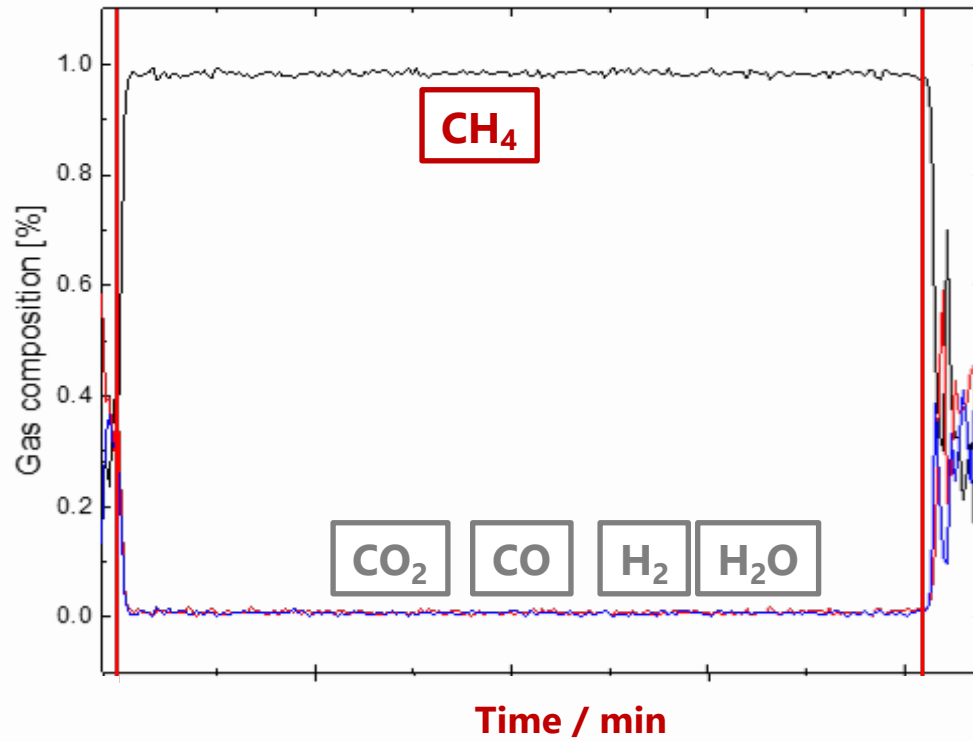
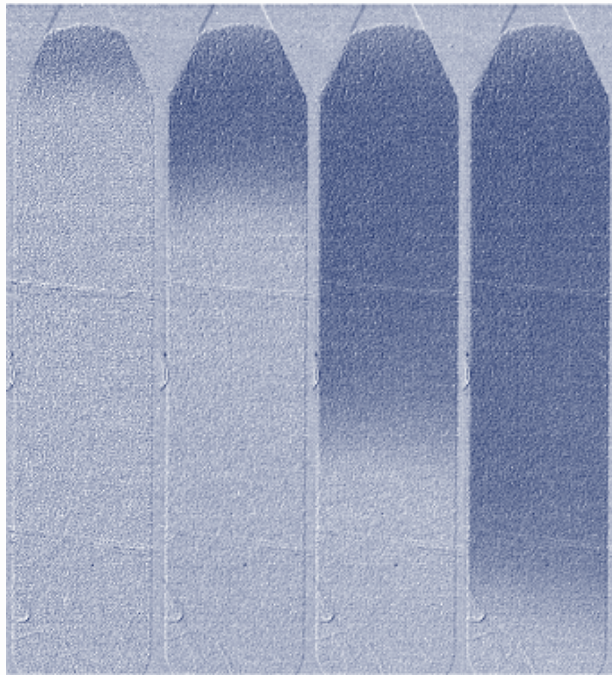
- **functional** material → Al<sub>2</sub>O<sub>3</sub>
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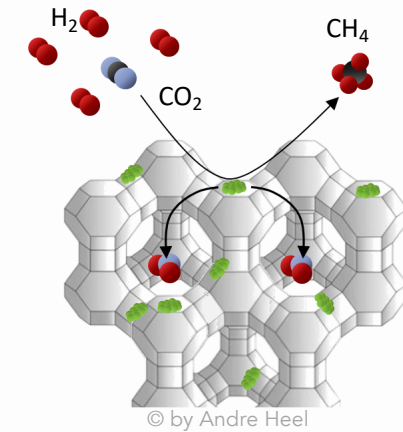
Acts like a «sponge» for H<sub>2</sub>O



SmartCat II → Sorption Enhanced  
SmartCat I → Self-Regeneration

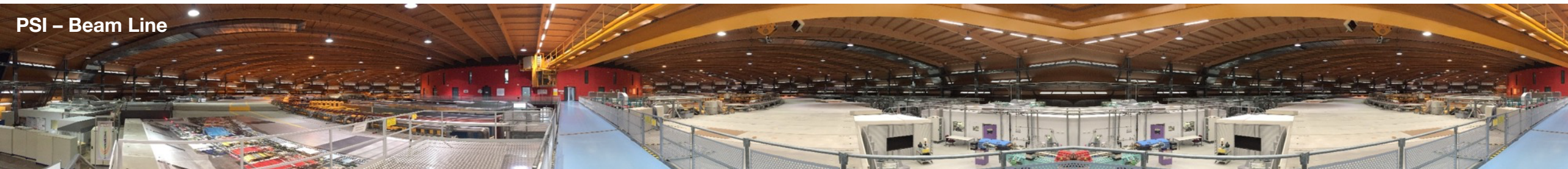


- 100% H<sub>2</sub> conversion & CO<sub>2</sub> conversion
- No secondary products (CO, C<sub>x</sub>H<sub>y</sub>)
- 100% selectivity to CH<sub>4</sub> (> 96%)



1 cycle = 40 min

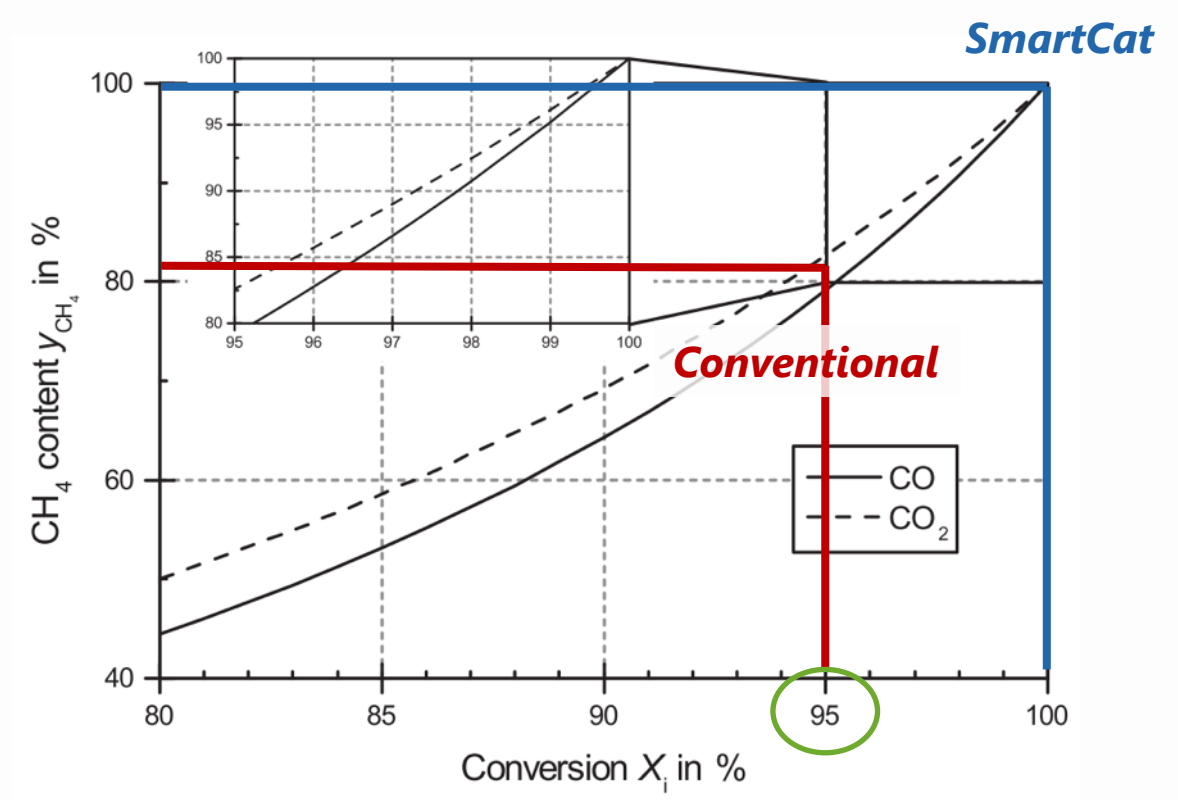
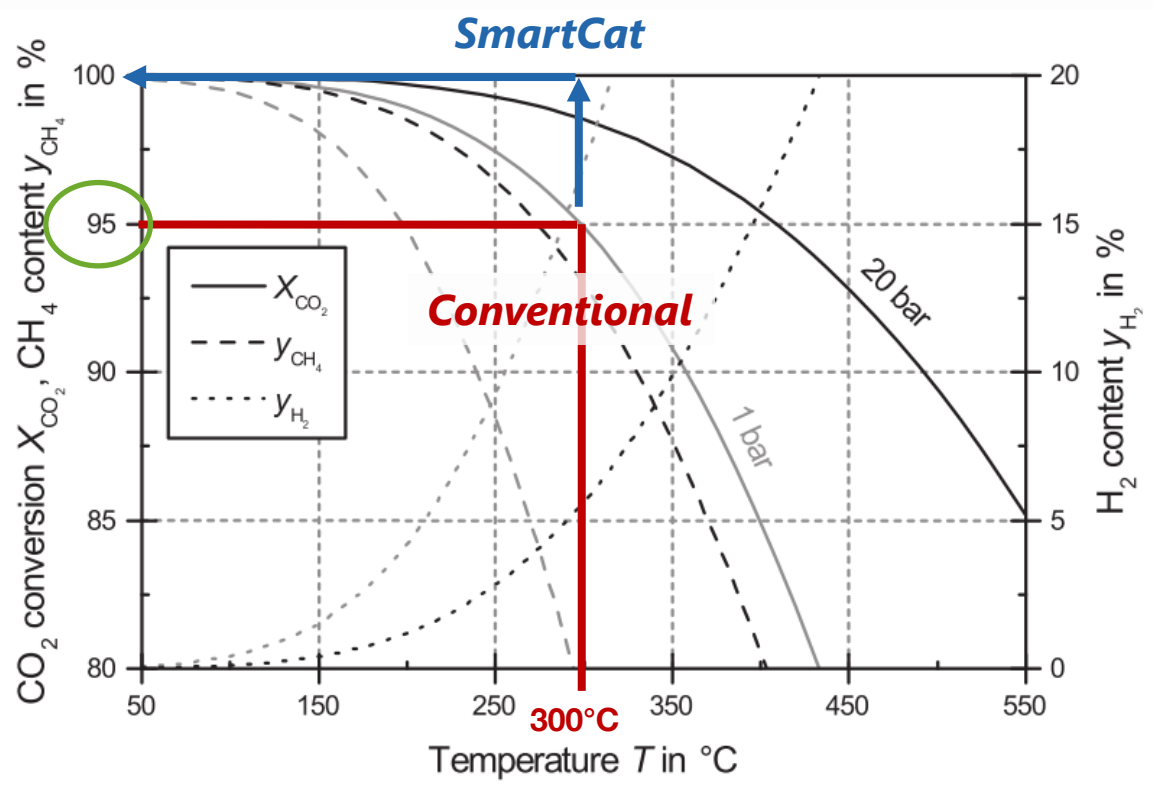
Borgschulte, Delmelle, Duarte, Heel et al. (2016). Water distribution in a sorption enhanced methanation reactor by time resolved neutron imaging. DOI: 10.1039/c5cp07686b  
 Delmelle, Duarte, Franken, Burnat, Holzer, Borgschulte, Heel (2016). Development of improved nickel catalysts for sorption enhanced CO<sub>2</sub> methanation. DOI: 10.1016/j.ijhydene.2016.09.045





# The Innovation

## Boosting the Efficiency & Sustainability



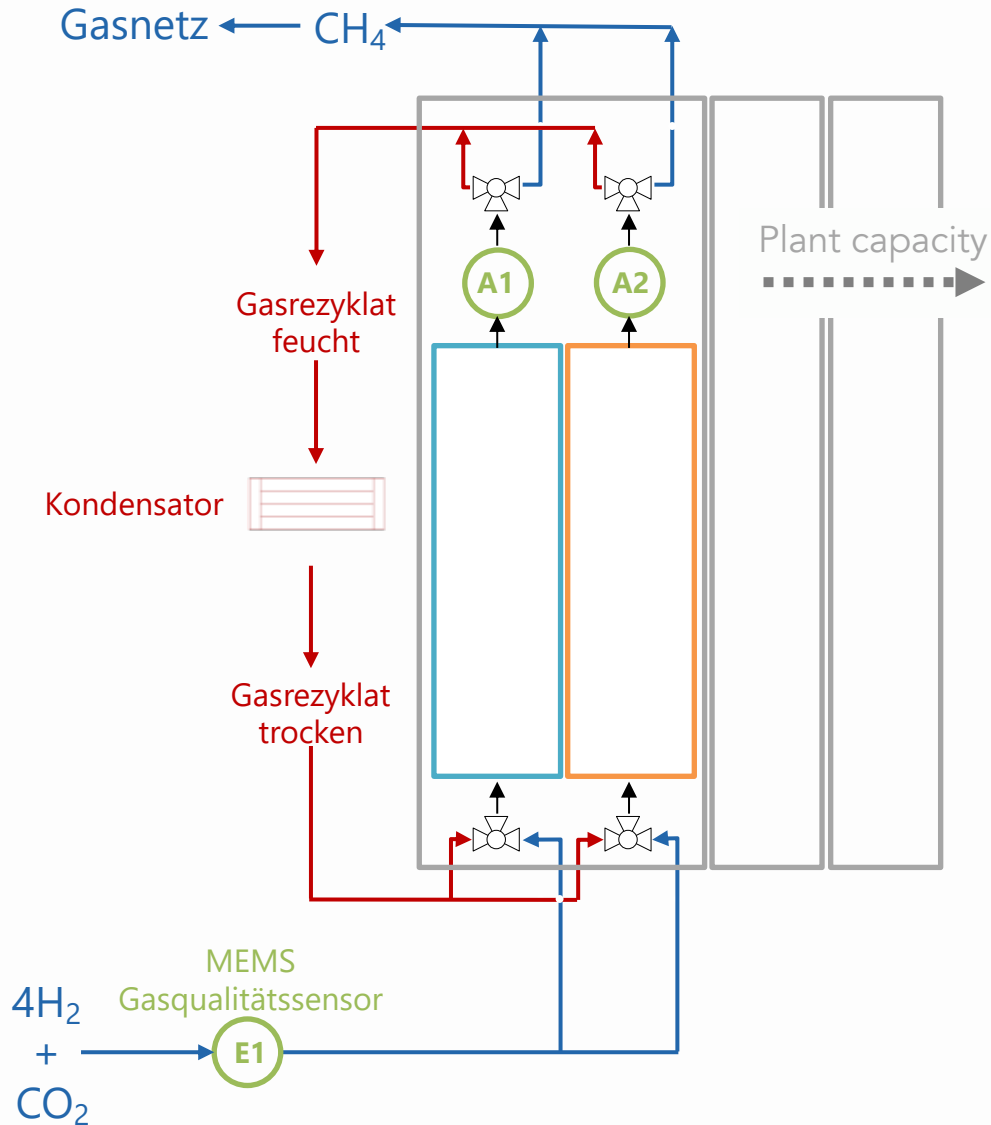
### Conventional

- Thermodynamic limitation → CH<sub>4</sub> quality insufficient: ~82%
- Costly gas purification & recycling (Capex/Opex)

### Innovative SmartCat

- No „limitation“ → CH<sub>4</sub> quality: 100%
- Maximum efficiency & Direct grid injection

# Industrialisation Automatisation & Scale-Up



Cycle time



## Industrial implementation partner

**mems** AG

Gas quality management (Wobbe,  $H_o$ ,  $H_u$ )  
Sensing & reactor control

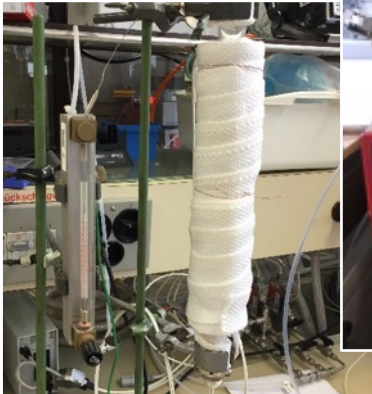
→ Autonomous operation (gas quality)

Industrial reactor design  
Upscaling:  $\varnothing = 2 - 3\text{m}$   
 $L = > 10\text{m}$

→ Reactor design & production

# From SmartCat to SmartHife<sup>2</sup>

100 mg



SmartCat  
idea

100 g



1 kg



15 kg



semi-industrial plant  
**IET@OST**

SmartHife<sup>2</sup>

**Cheap**  
**Environmental-friendly**

Less sensitive to S



State of the Art: Ni

Carcinogen  
Hazardous  
Sulfur sensitive

2015...

2020

2021

2021 - 2023

SmartCat  
implemented

BFE  
SmartHife<sup>2</sup>

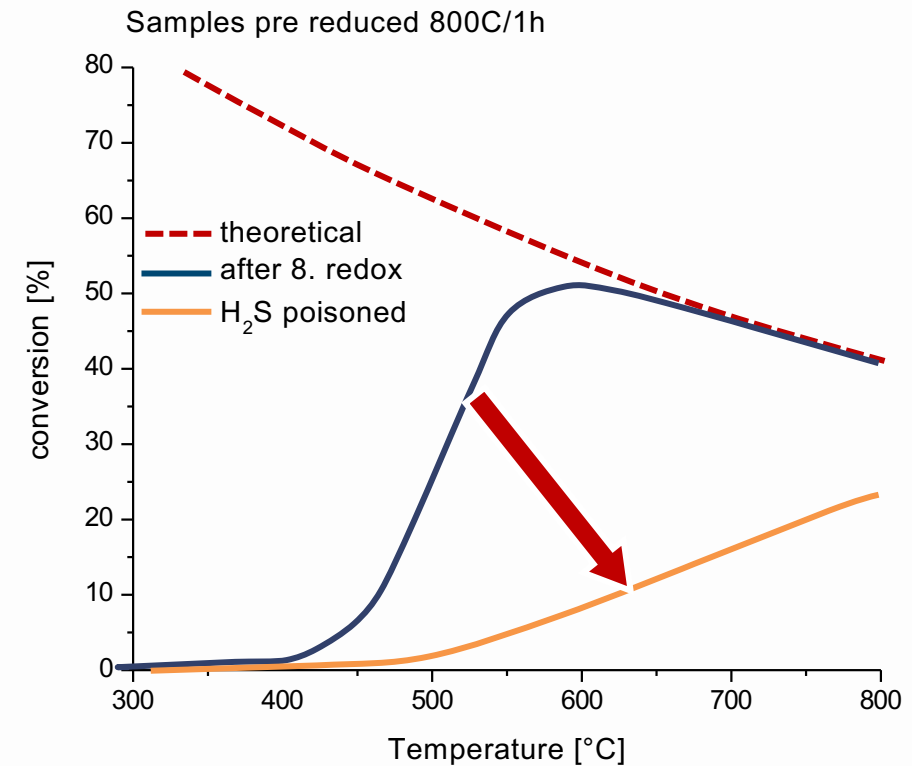
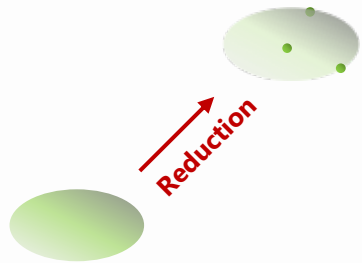
# SmartCat Technology II

## Catalytic Poisoning from H<sub>2</sub>S

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### Regeneration LST<sub>355</sub>-5Ni

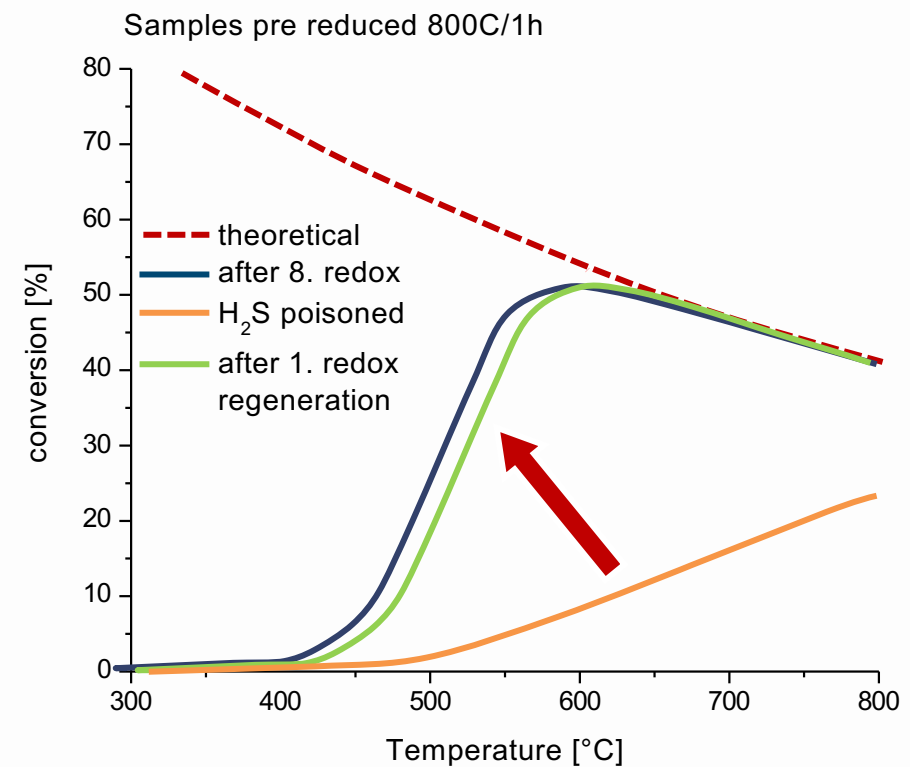
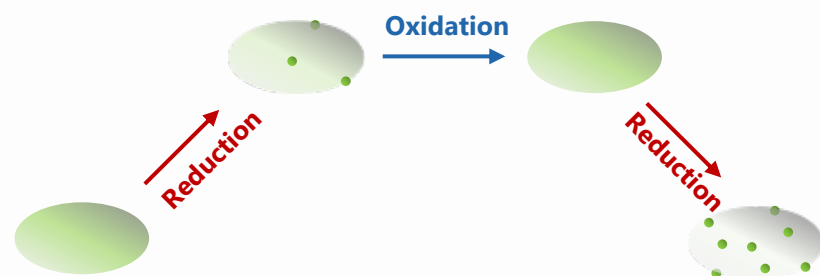
- Severe effect of sulfur on catalytic activity observed



100ppm H<sub>2</sub>S

### Regeneration LST<sub>355</sub>-5Ni

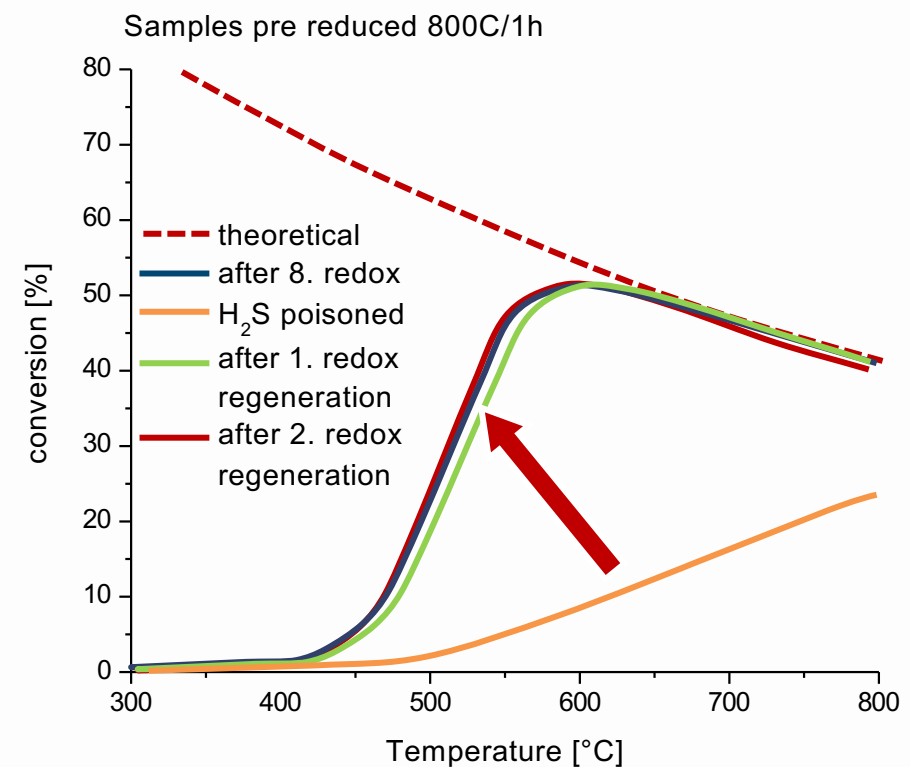
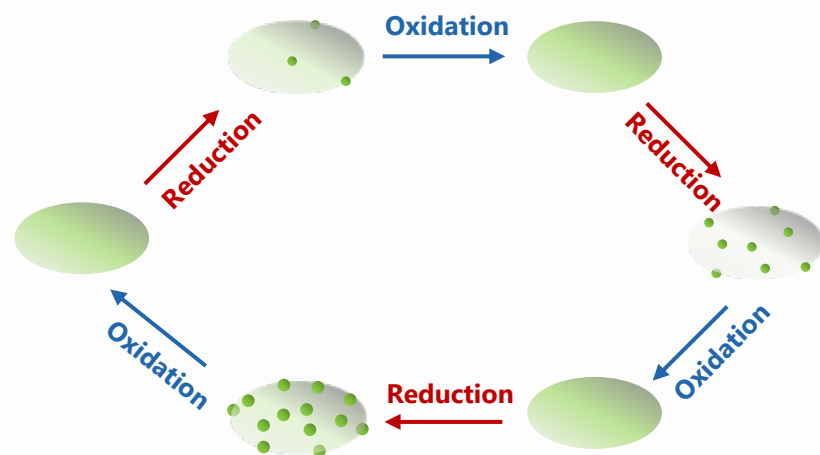
- Severe effect of sulfur on catalytic activity observed
- Almost complete regeneration after 1. redox cycle



100ppm H<sub>2</sub>S

### Regeneration LST<sub>355</sub>-5Ni

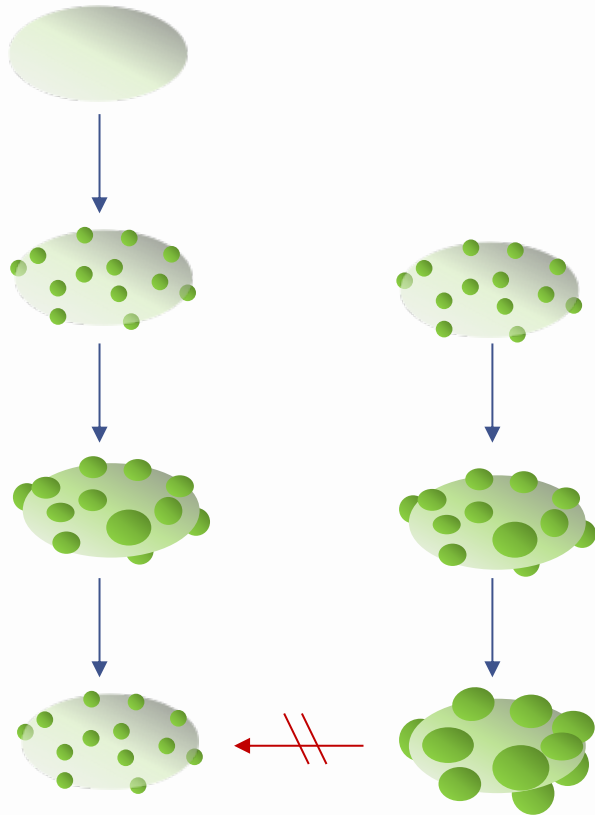
- Severe effect of sulfur on catalytic activity observed
- Almost complete regeneration after 1. redox cycle
- 100% complete after a 2. redox cycle



100ppm H<sub>2</sub>S

SmartCat

Conventional



Suitable for accessing critical gas compositions with strong gas contaminants or

- PtG
  - KVA
  - Cement exhaust gas
  - Biogas
- Other catalytic systems ...PtX
- SOFC: Natural gas with S as odorant



Thank you for your attention!