



OST
Ostschweizer
Fachhochschule

A novel iron-based catalytic biogas upgrade concept

SmartHiFe²

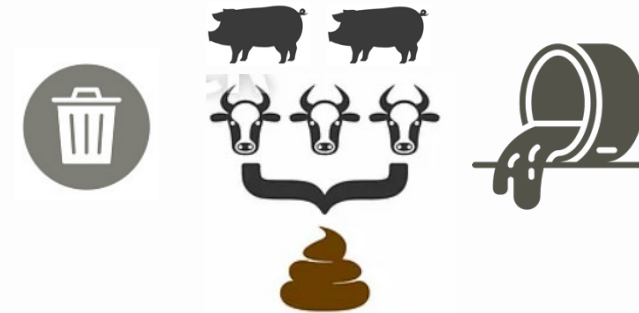
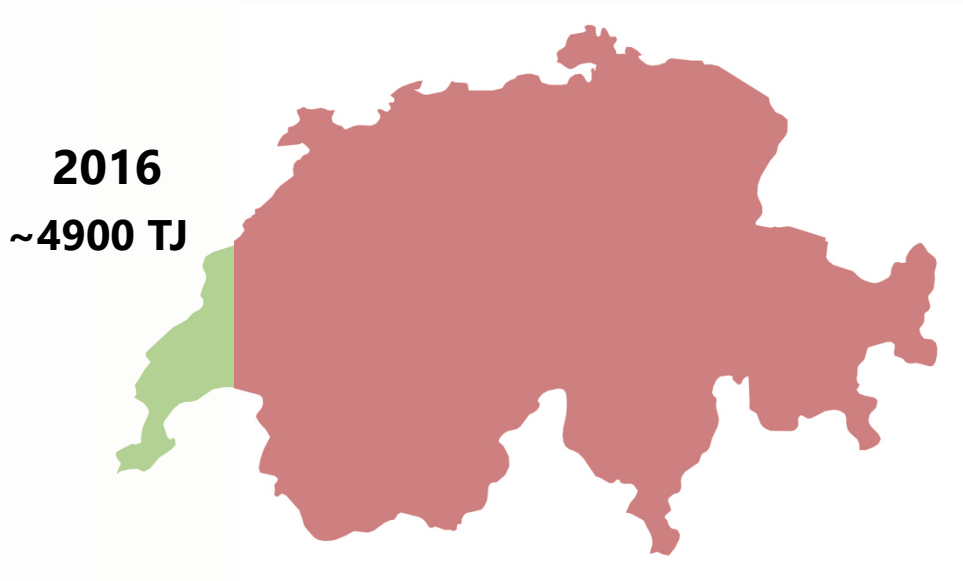
BFE PN: SI/502053-01

Stefanie Mizuno & Andre Heel

Advanced Materials & Processes, UMTEC

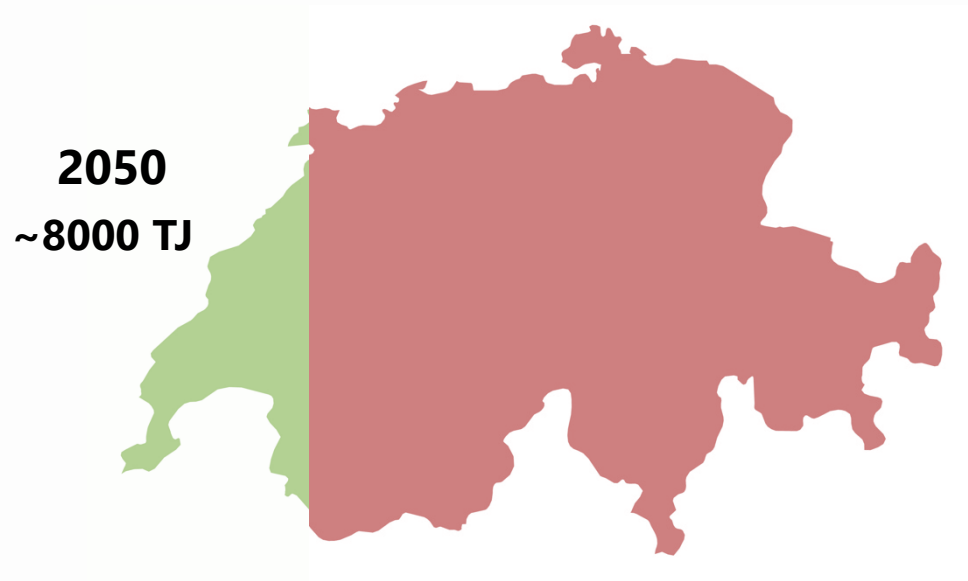


Biogas production in Switzerland:



- 24 % - Electricity
- 33 % - CHP / Industrial burners
- 20 % - Upgraded to Biomethane
- 23% handling/parasitic heat losses

Biogas production in Switzerland:

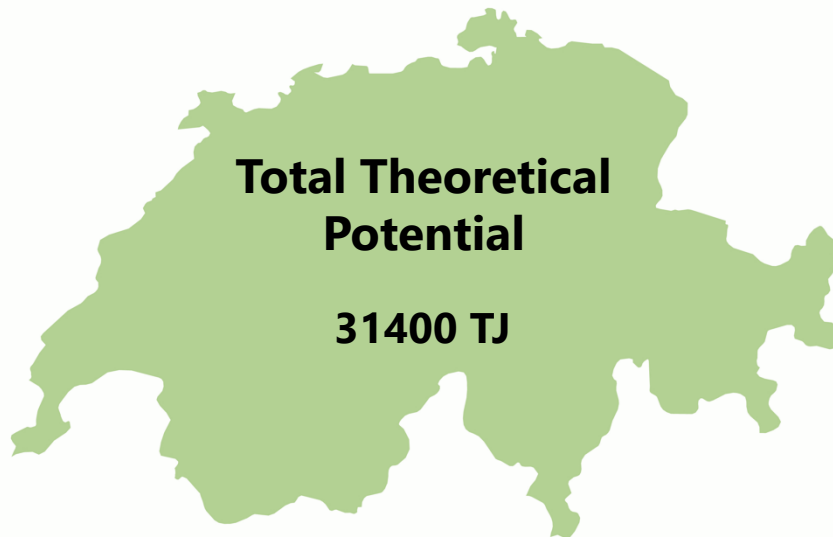


Is expected a production of ~8000 TJ by 2050

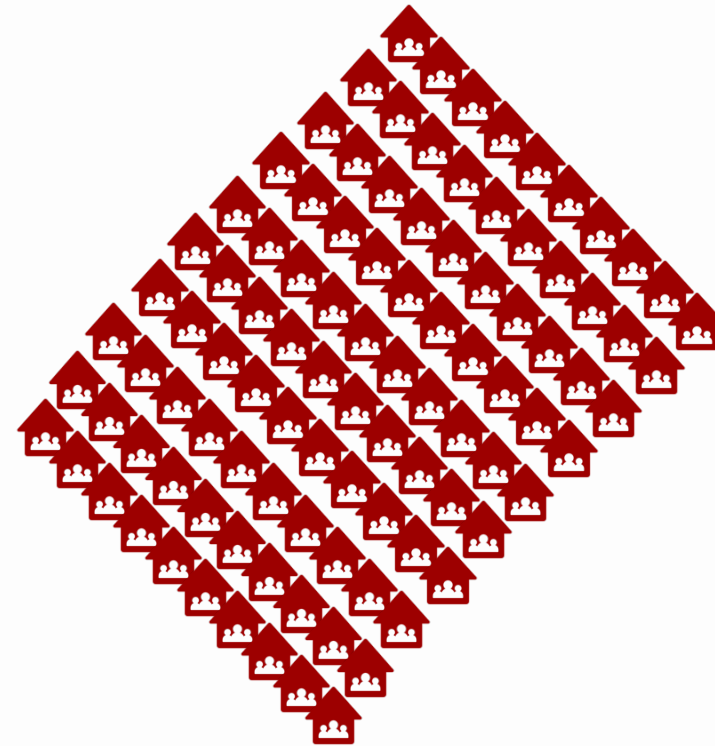
Swiss gas industry new goal: increase the use of renewable methane/biogas in the **heating market up to 30% in 2030**

How to achieve this goal?

Biogas production in Switzerland:

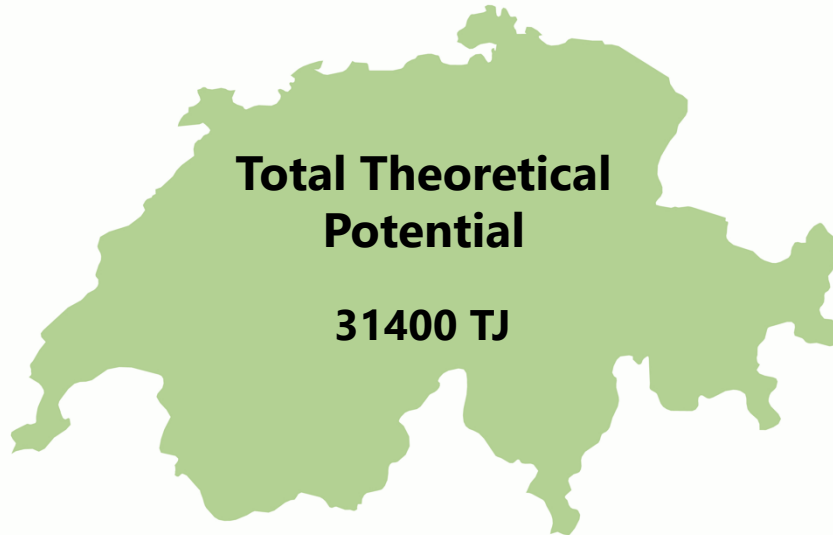


➤ **Losses could be about 7000 TJ !!!!**



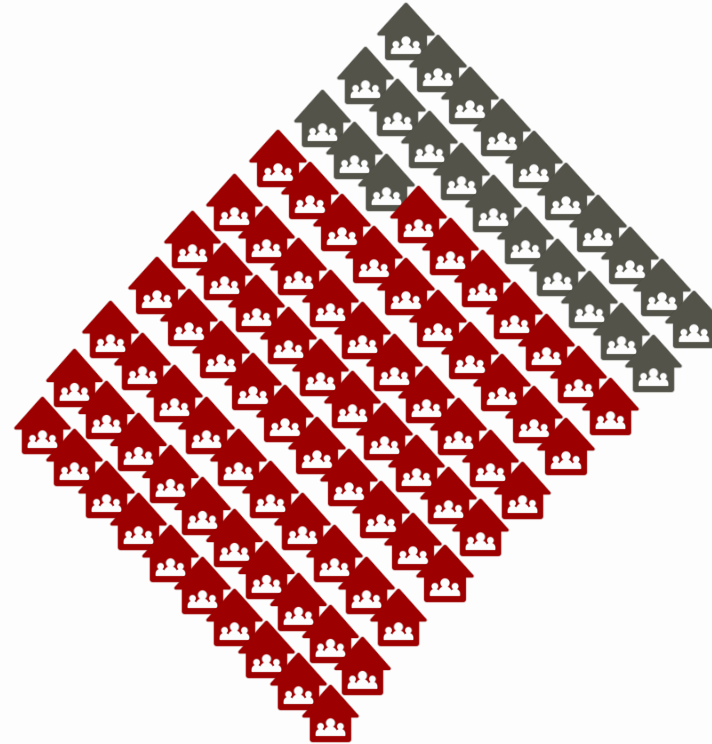
Energy wasted would be enough to supply 400000 Swiss households

Biogas production in Switzerland:



➤ **Losses could be about 7000 TJ !!!!**

How to decrease the losses and expand biogas use in the heat market?

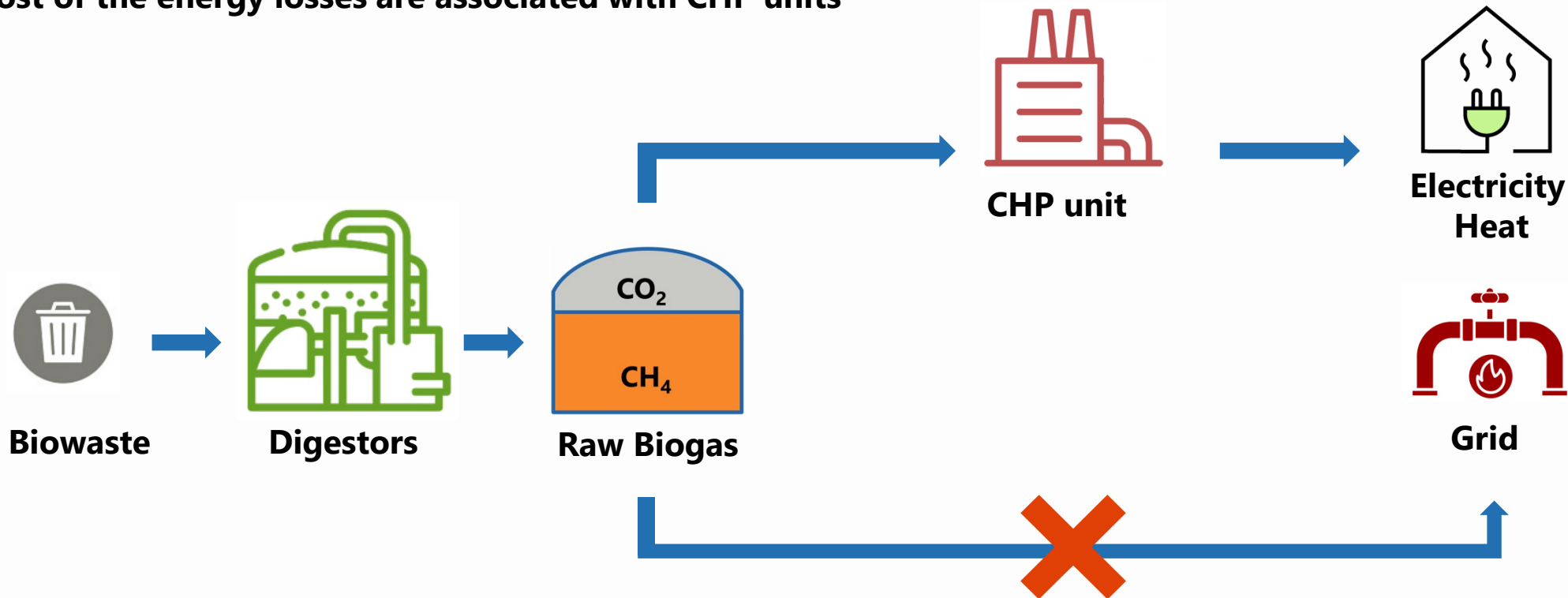


Energy wasted would be enough to supply 400000 Swiss households

Why upgrade biogas?

Raw biogas cannot be directly fed into the grid

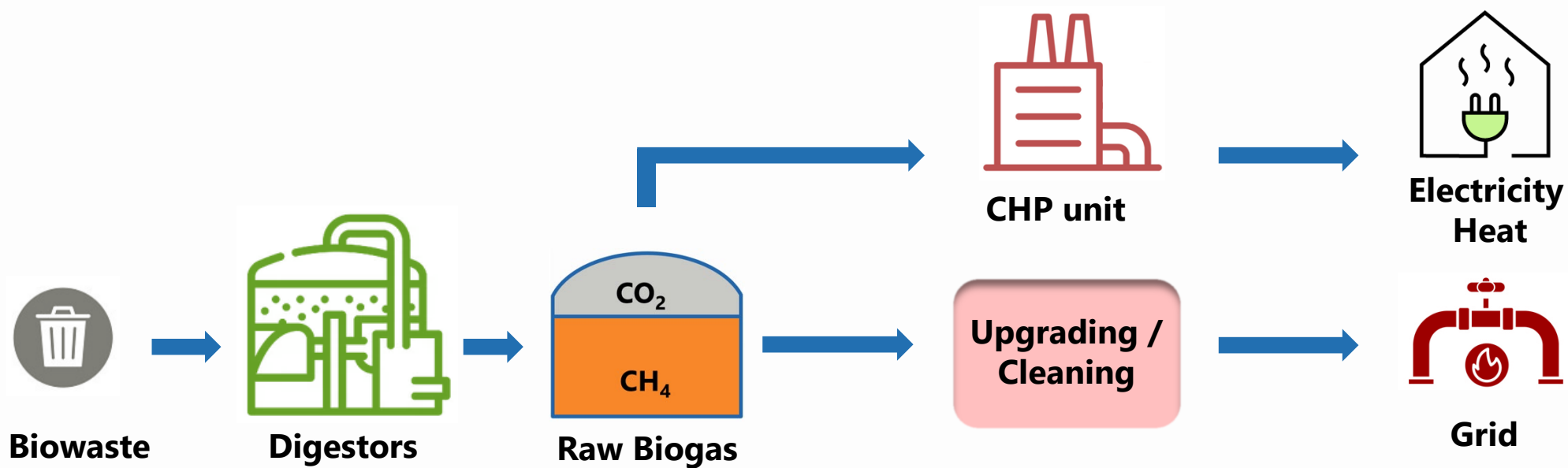
Most of the energy losses are associated with CHP units

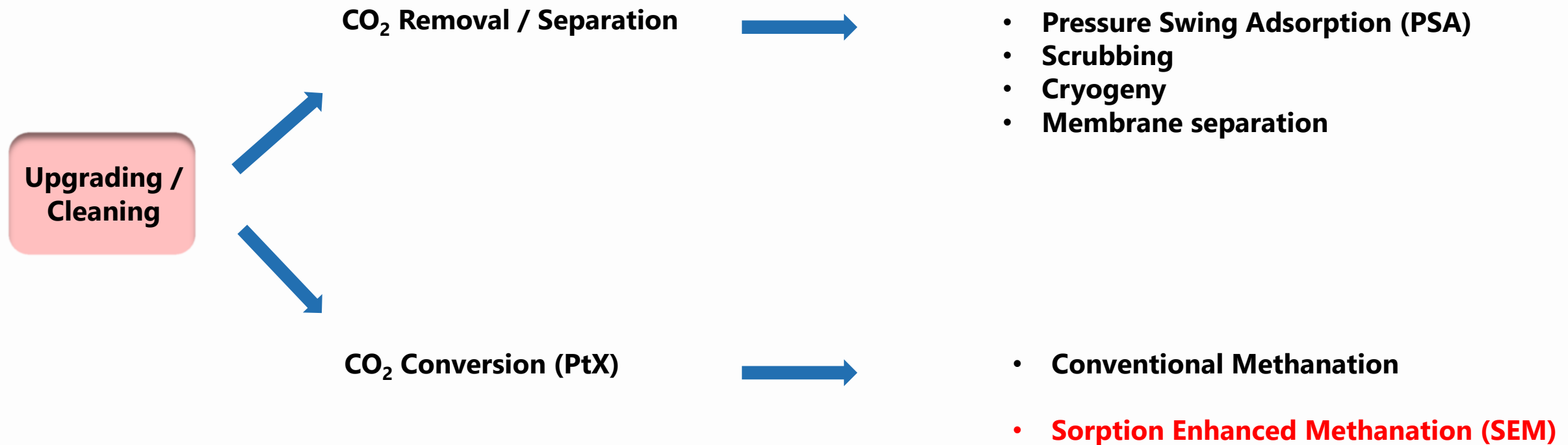


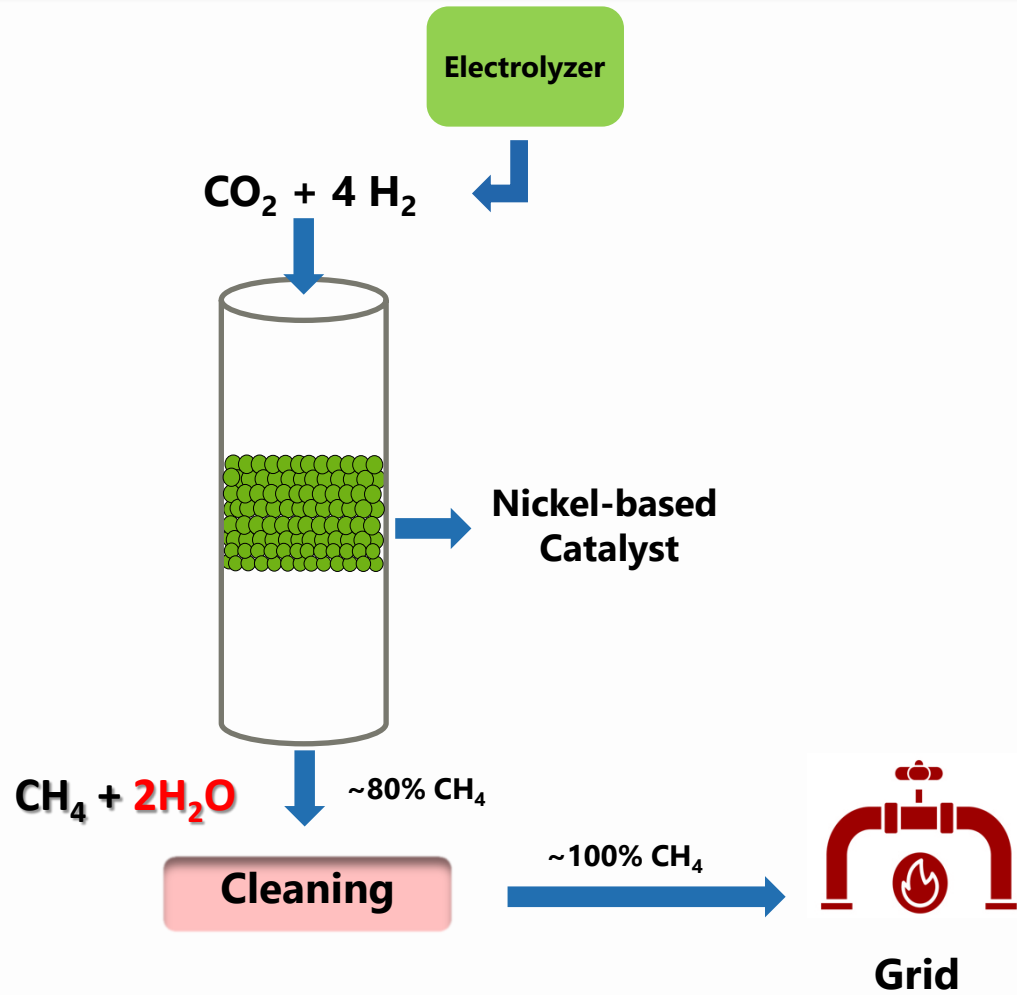
Why upgrade is needed?

Expansion of biogas use in the domestic heat market

Investments in Upgrading/Cleaning are needed

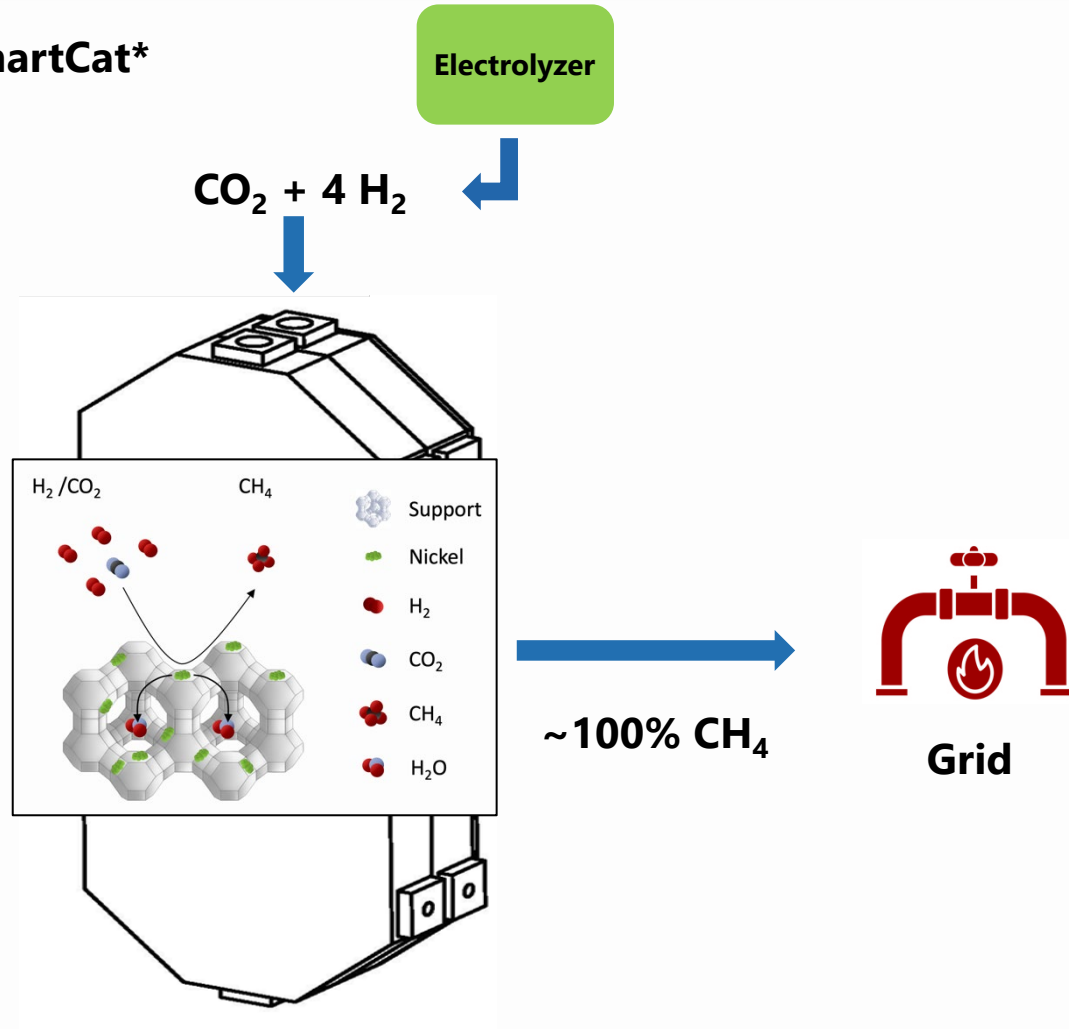




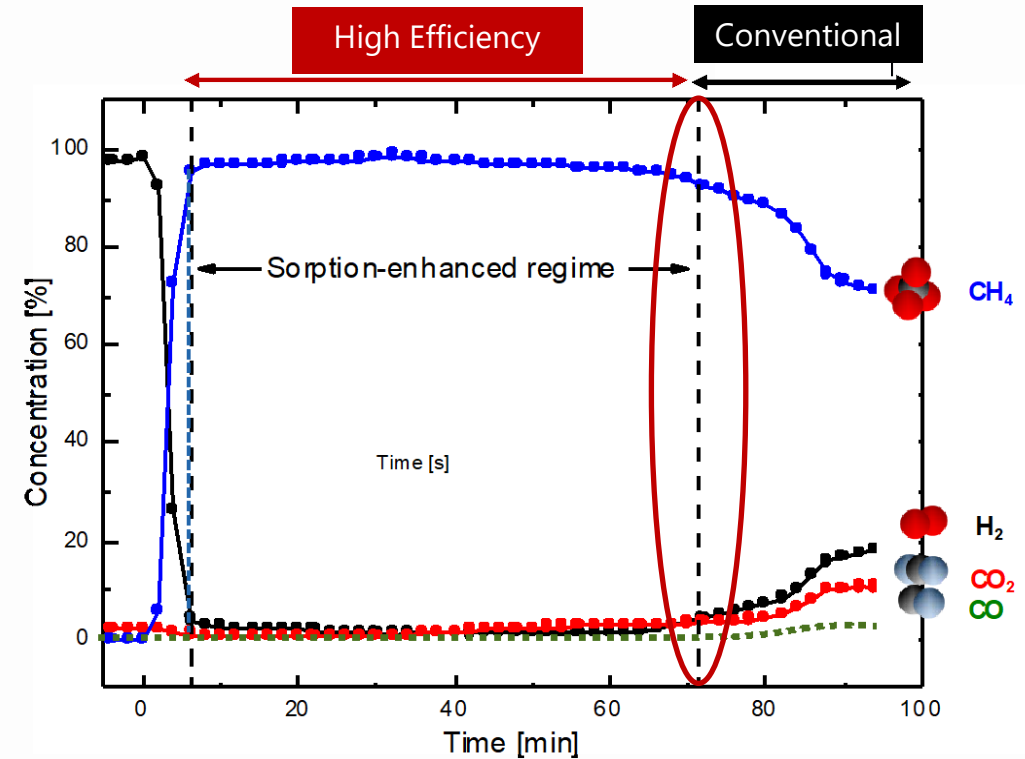


Expensive purification step needed!

SmartCat*



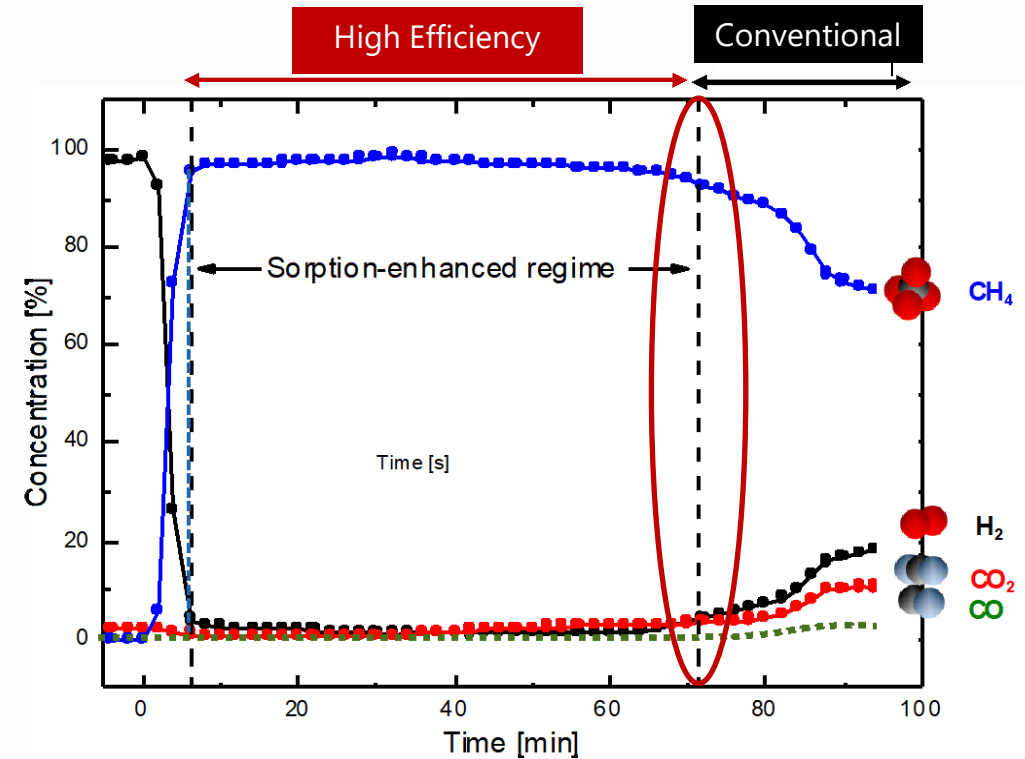
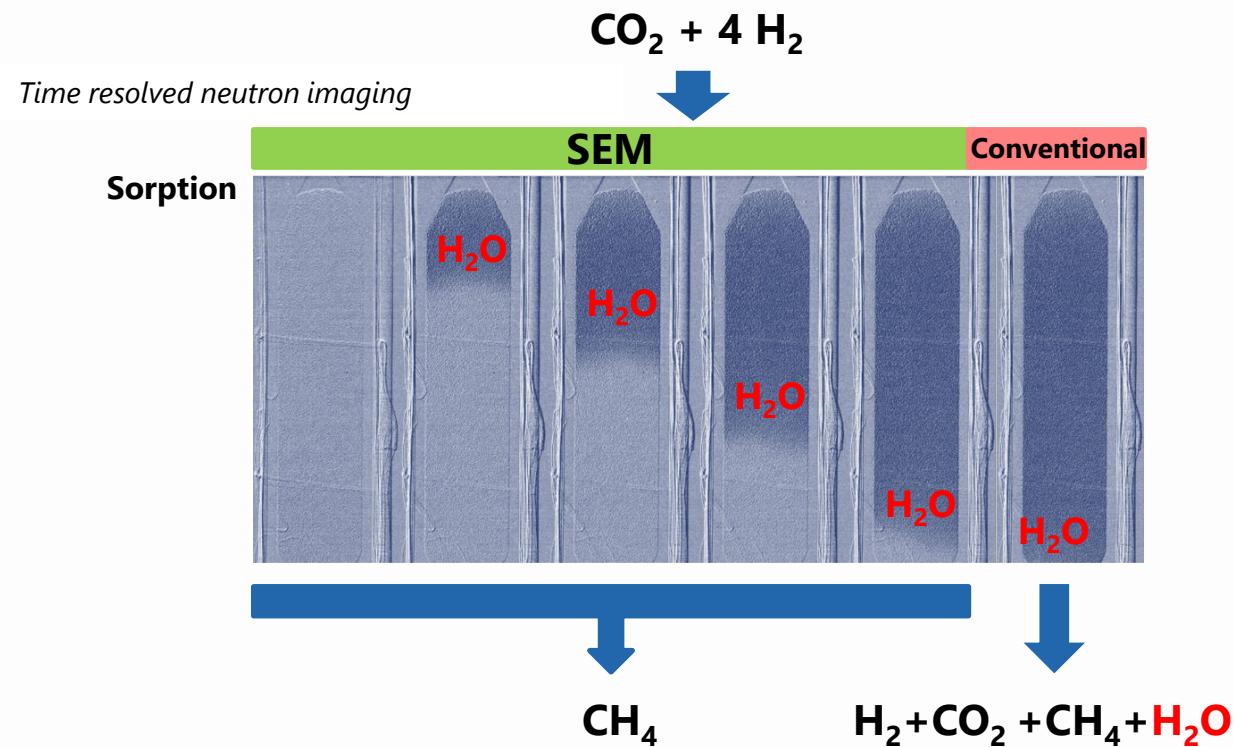
Direct injection into the gas grid!



100% Biomethane & no byproducts!

SmartCat*

SmartCat «catches» the water shifting
the reaction to the product side with
100 % CO₂ Conversion



100% Biomethane & no byproducts!

Replacement of **Nickel (SmartCat)** by **Iron (Fe)**

Pro- List:

✓ 100 times cheaper than Nickel



✓ Highly available



✓ Non-toxic



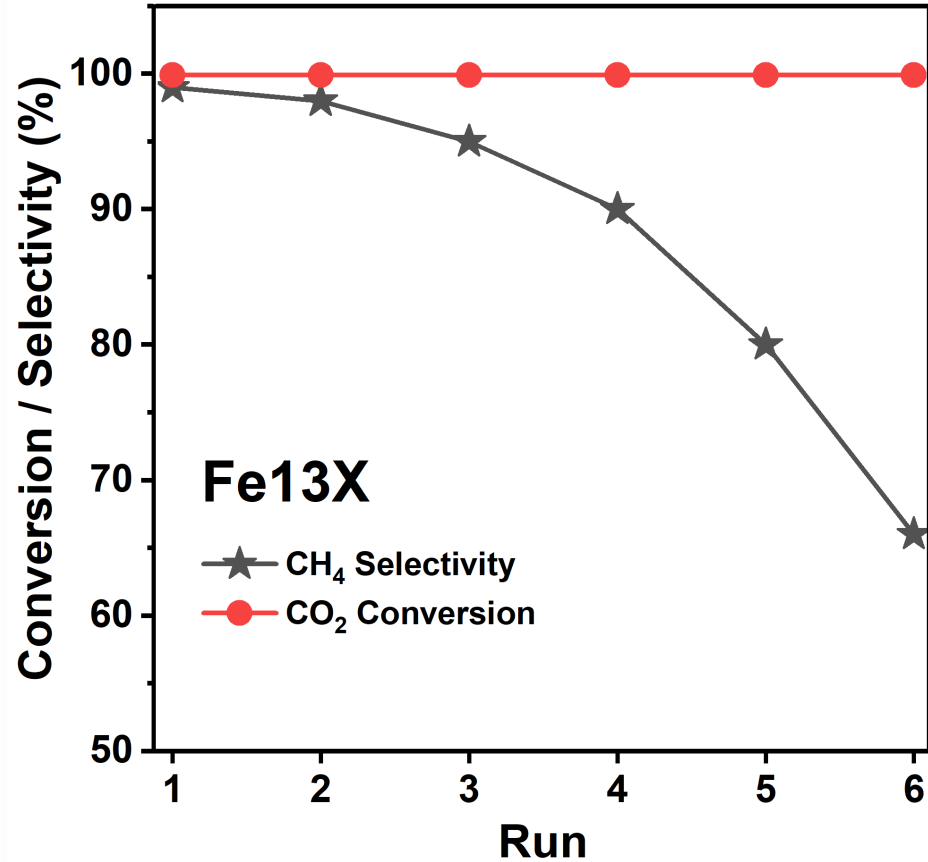
Challenge

✓ Technology transfer not easy (≠ parameters)

A higher oxidative state of Iron requires a different
Synthesis technique (newly developed)



Synthesized Fe13X materials



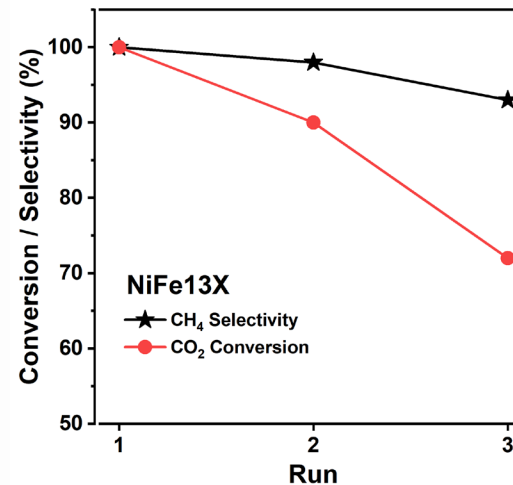
CH₄ Selectivity and CO₂ conversion per run for the Fe13X material in Sorption mode.
Conditions: T= 400°C / Pressure= 15 bar / GHSV~ 100 h⁻¹.

100 % CO₂ conversion & 99 % CH₄ Selectivity in the first run

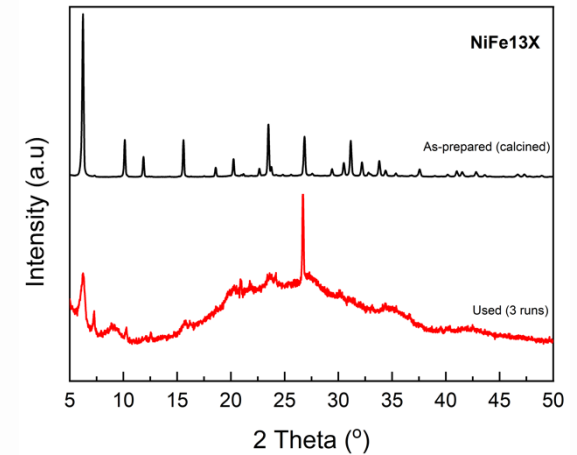
Significant decrease of selectivity after few runs

Conversion is maintained but >CO formation

**Material enhancement by adding 0.25% (w.t.) of Nickel
(Total w.t.= 1%)**

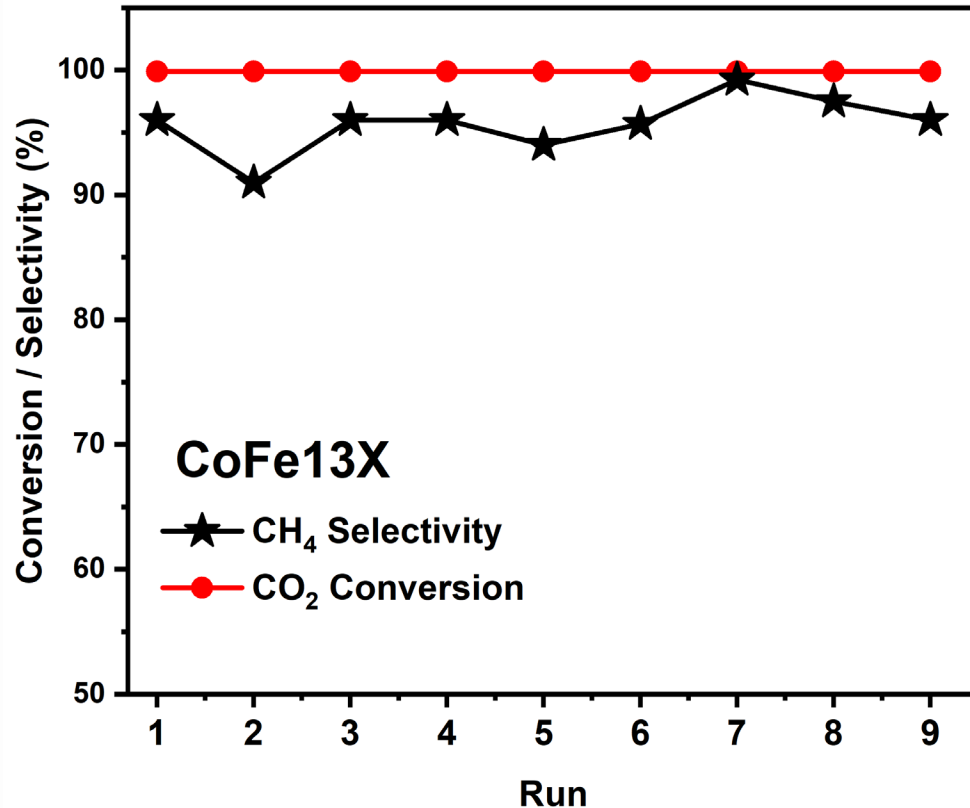


Decrease of conversion



Material structure degradation

Material enhancement by adding small amounts Cobalt



CH₄ Selectivity and CO₂ conversion per run for the NiFe13X material in Sorption mode.
Conditions: T=400°C / Pressure= 15 bar / GHSV~ 100 h⁻¹.

100 % CO₂ conversion with average of 96 % CH₄ Selectivity during 9 runs

75% of the Nickel content was successfully removed from the process

Cheaper material with high stability and CH₄ selectivity

Newly developed synthesis procedure easily scalable

From the process side...

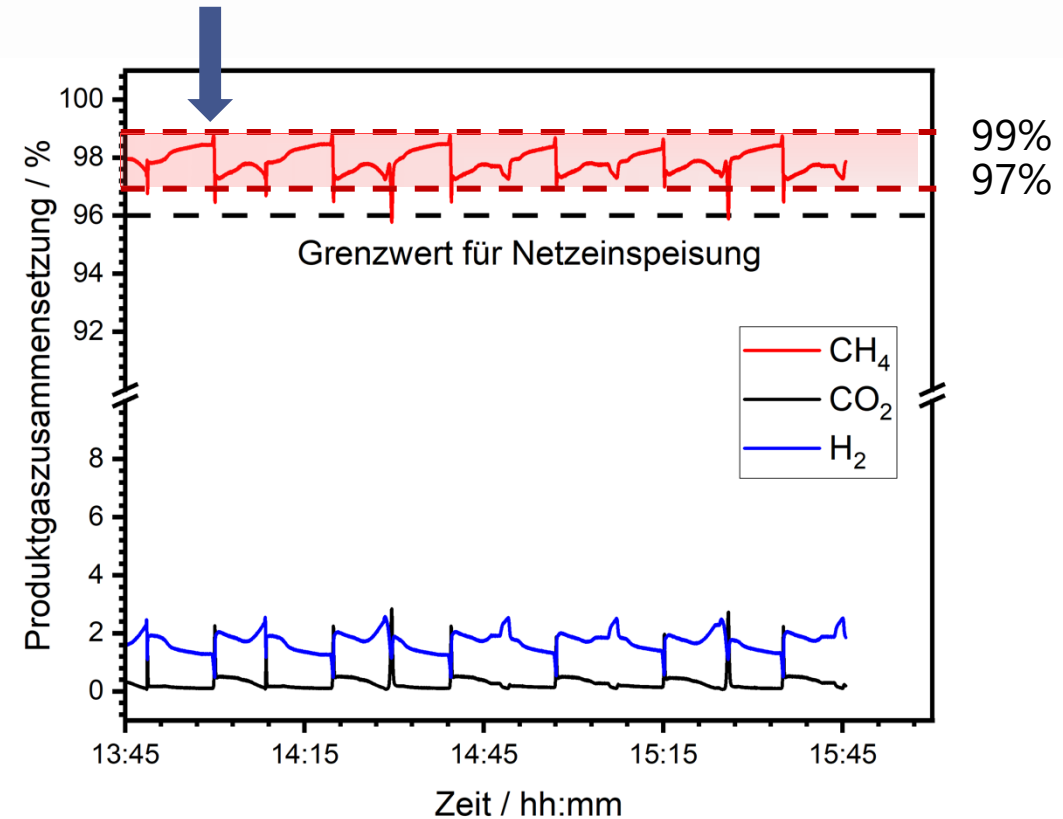
GASEM* project

Twin-reactors equipped with **mems^{AG}** sensors



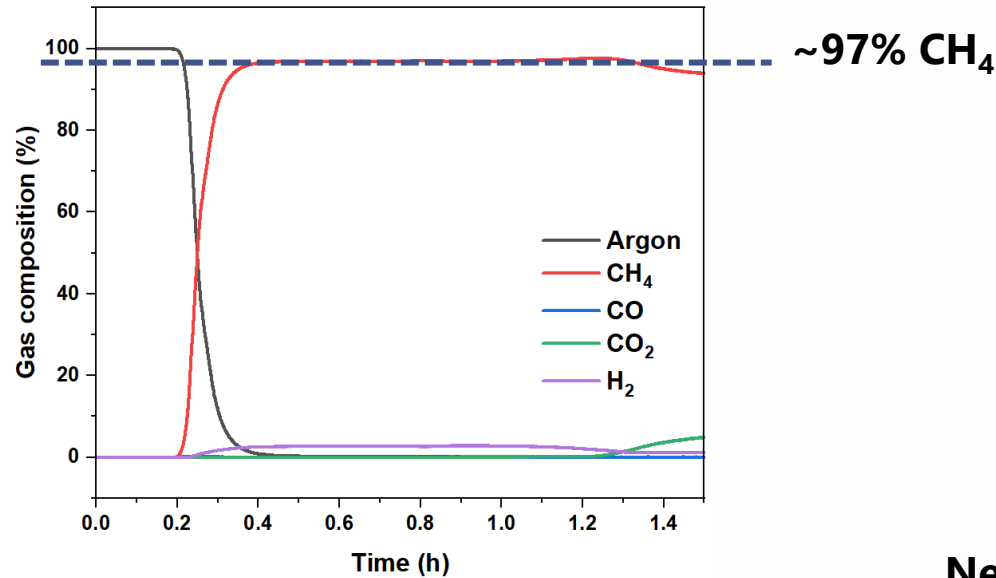
**Simultaneous
Methanation and Regeneration**

Sensor triggers the reactor switch



**Automated SEM unit (twin-system) allows
continuous production of high quality
biomethane (99-97%)**

10 L reactor developed with our partner Fluitec



Methanation results in gas composition versus time.
Catalyst: Ni13X. Conditions: T=300°C, 1bar, GHSV~ 100 h⁻¹

Testing the SmartCat under realistic conditions



**New reactor design “hotspots-free”
(Patent submitted)**

**«Industry-ready»
Scalable up to D=2 m**

Better understanding of operational parameters

Innovative reactor with accurate temperature control ($\Delta T < 5K$)



fluitec
mixing + reaction solutions

SmarthiFe technology status

...

From the LAB

to

Industry



Fe-based materials
are functional



Twin-reactor
system



Hotspot-free
reactor

Process development
SmartCat



SMARTHIFE² TECHNOLOGY

Installation sites for pilot plant identification
Real site testing (gas composition)



Cheaper, less toxic and
environmentally friendly materials



THANK YOU FOR YOUR ATTENTION!!!

Delmelle, R., Terreni, J., Remhof, A., Heel, A., Proost, J. & Borgschulte, A. (2018): Evolution of Water Diffusion in a Sorption-Enhanced Methanation Catalyst. Catalysts 8, 341, doi:10.3390/catal8090341.

Kirchner, J., Anolleck J. A., Lösch H., Kureti S. (2018): Methanation of CO₂ on iron based catalysts. Applied Catalysis B: Environmental 223, 47, doi: 10.1016/j.apcatb.2017.06.025.

Franken, T., Heel A. (2020): Are Fe based catalysts an upcoming alternative to Ni in CO₂ methanation at elevated pressure?. Journal of CO₂ Utilization 39, 101175, doi:10.1016/j.jcou.2020.101175.