



First Workshop ARENHA project: “Introduction to novel technologies related to ammonia-based energy storage”

SOFC technology for hydrogen-based power generation

Christian Eckart

Contact: christian.eckart@ikts.fraunhofer.de

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I. Introduction

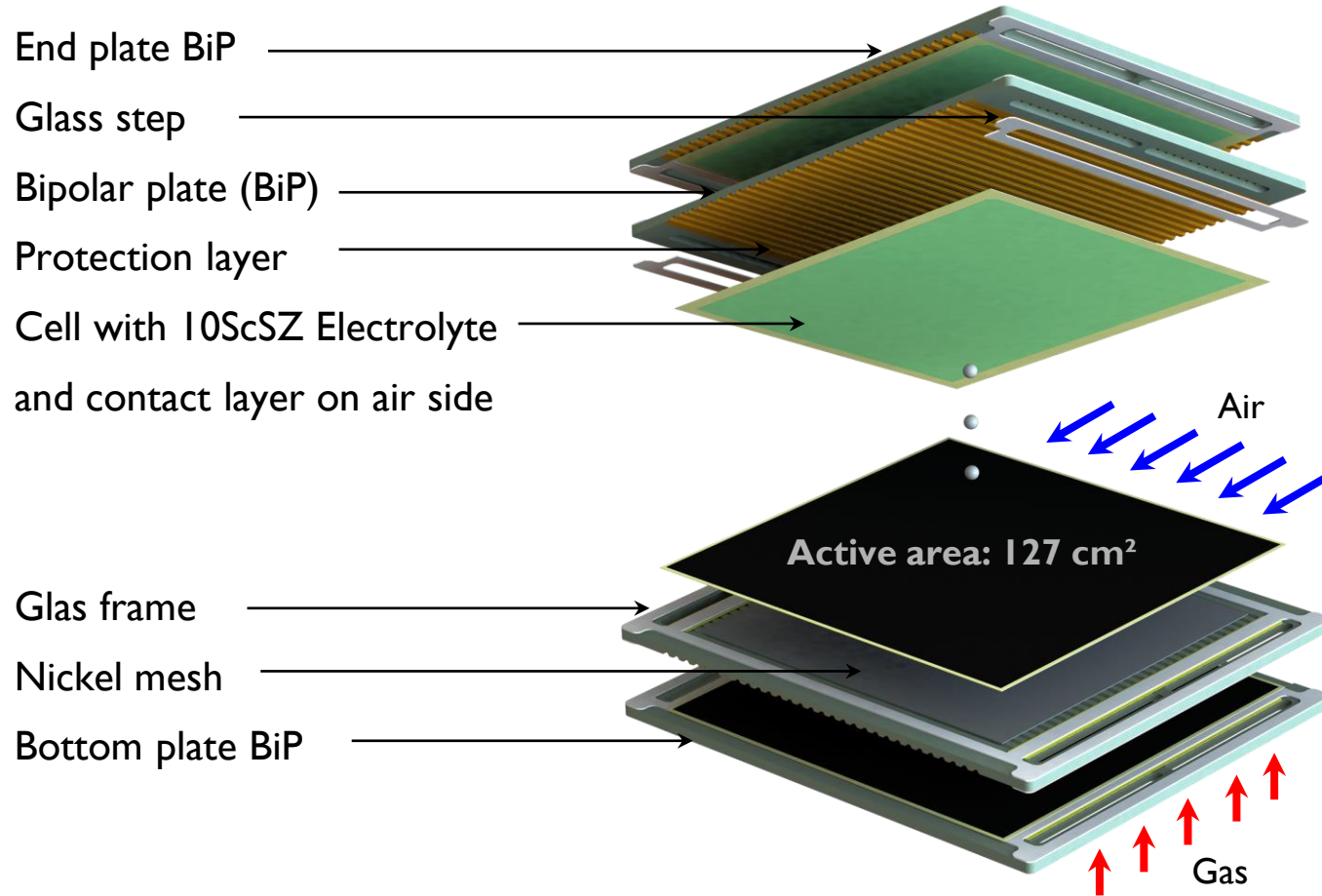
Intention

- SOC stack modules of 1-200 kW_{el} for decentralized power plants
- High electrical efficiency
- Robust low cost stacks with high reliability

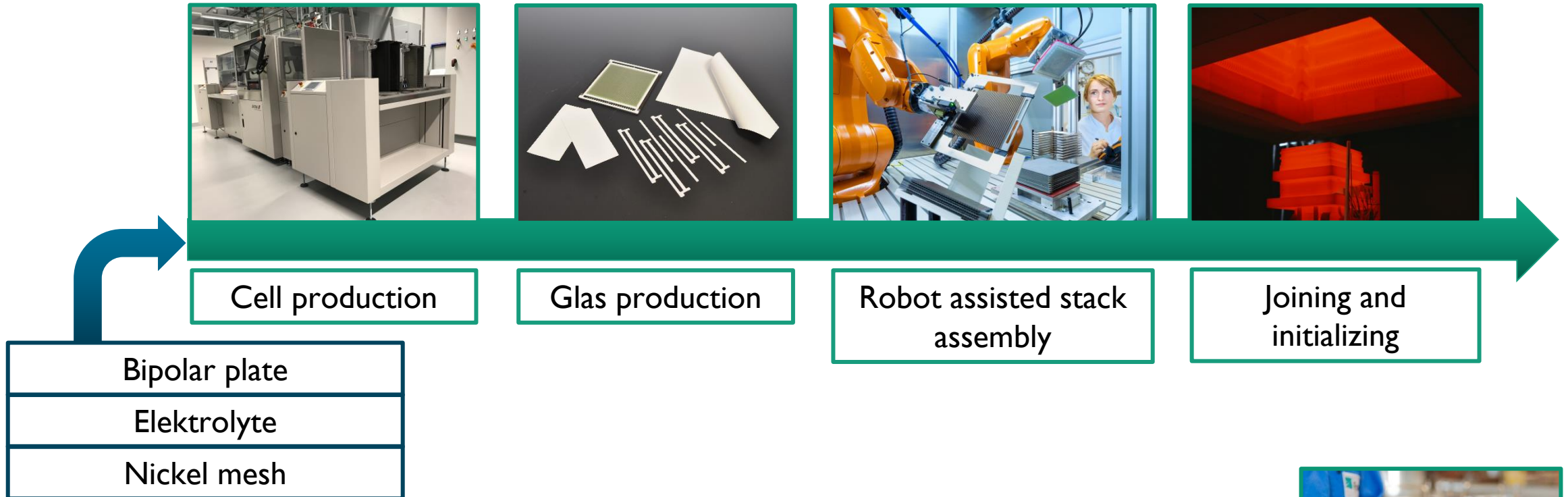
Core technology

- Near-net-shape interconnect: powder metallurgical processed and partially coated with protection layer
 - High power density cells with 10ScSZ electrolytes (electrodes from Fraunhofer IKTS)
 - MK35x-Stack development > 15 years
- ➔ MK355 Interconnect from Porite Taiwan (commercial production line)

2. Stack components MK354



2. Stack manufacturing MK35x



- Continuous component inspection
- Stacks with 10-40 cells

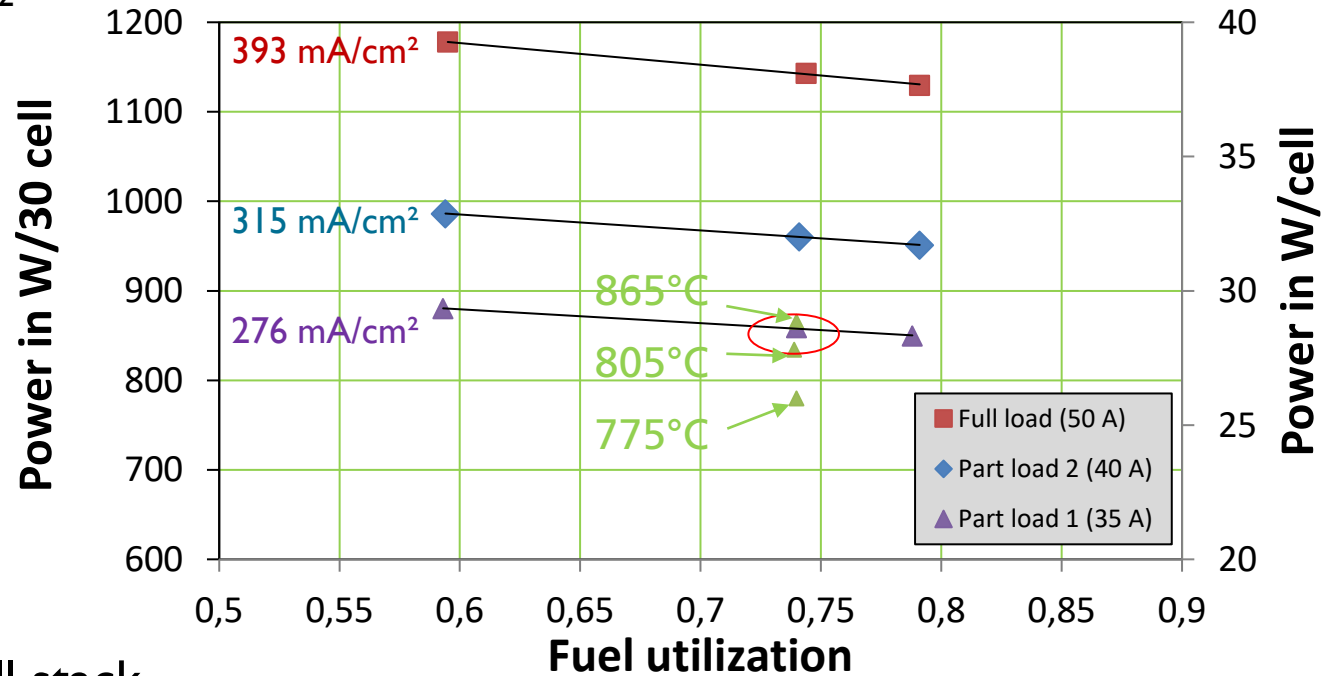


3. Stack results: SOFC performance map



MK352 30-cell stack in a hotbox: rated power operation

- Fuel: 40 % H₂ in 5 % H₂O and N₂
- Air: 100 sl/min
- T_{cat,o} = 830°C – 840°C



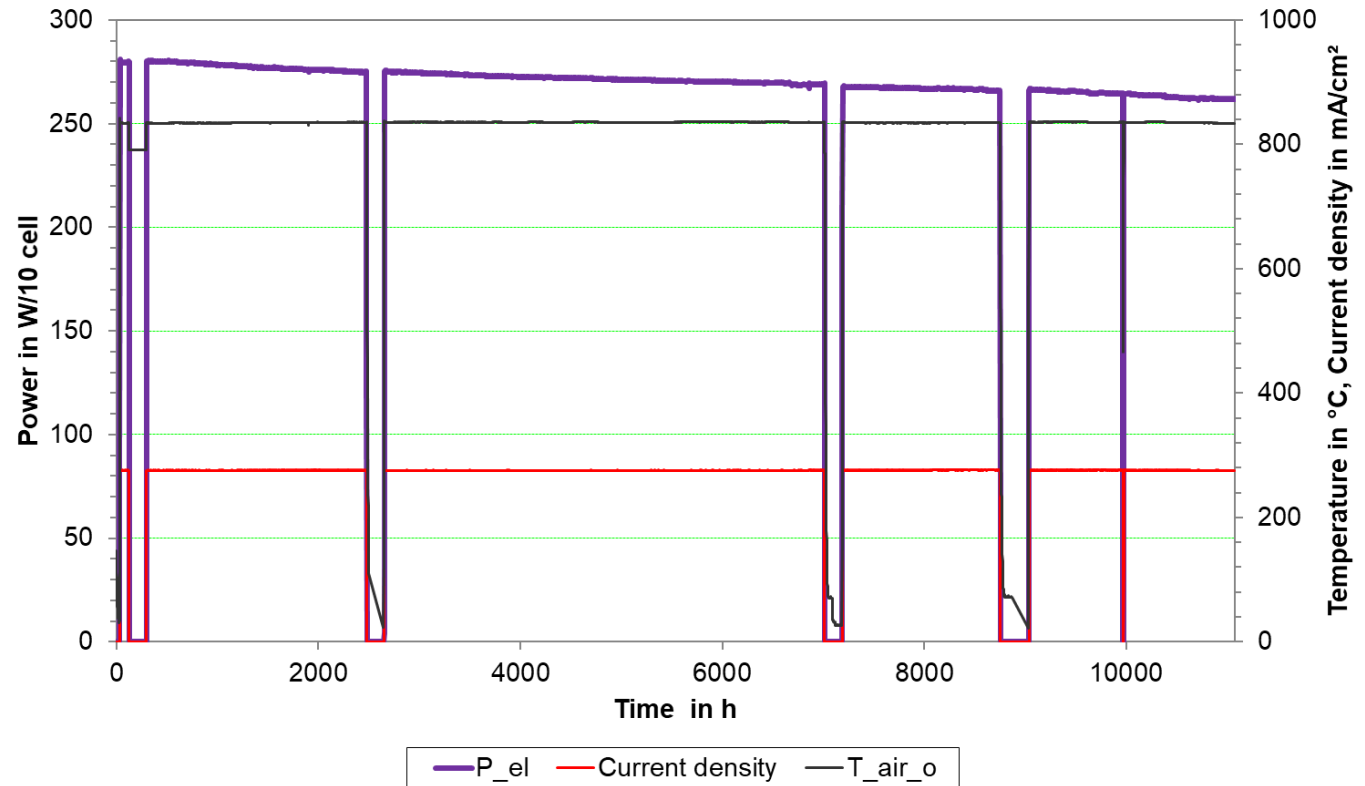
- At reference point 850 W/30 cell stack
- Up to 1200 W/30 cell stack possible

3. Stack results: SOFC long-term stability



MK354 10-cell stack in furnace:

- I=35 A
- FU=75 %
- Fuel: 40 % H₂ in N₂
- Air: 60 sl/min
- T_{cat,o} ≈ 835 °C



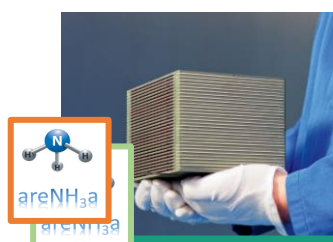
- $\Delta P/P_0 < 0.7\% / 1000\text{ h}$ ($> 10,000\text{ h}$); $\Delta ASR = 20\text{ m}\Omega\text{cm}^2 / 1000\text{ h}$



4. MK35x in ARENHA: Overview

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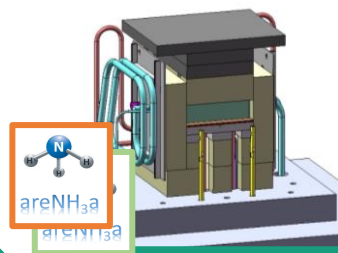
-  **ARENHA SOFC**
-  **ARENHA SOEC**



MK35x SOC stack with 10-40 cells



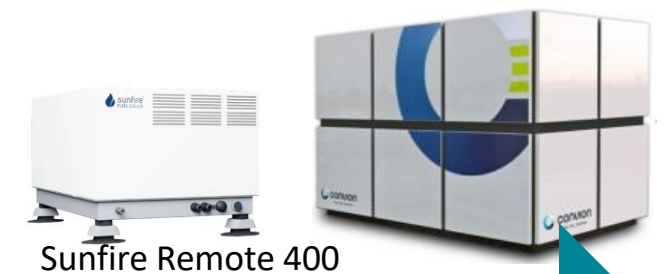
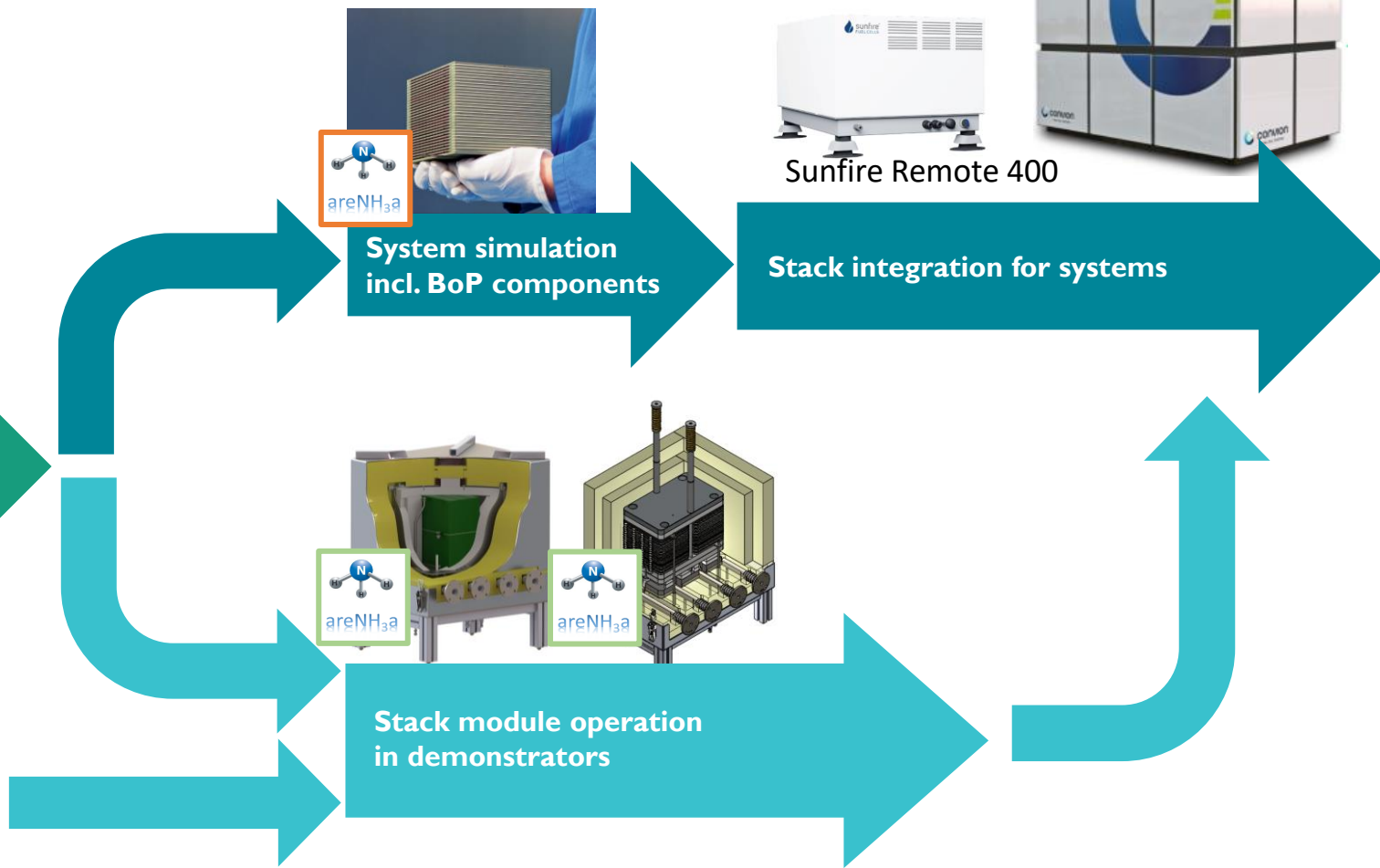
Cell development at IKTS



Stack tests in furnace



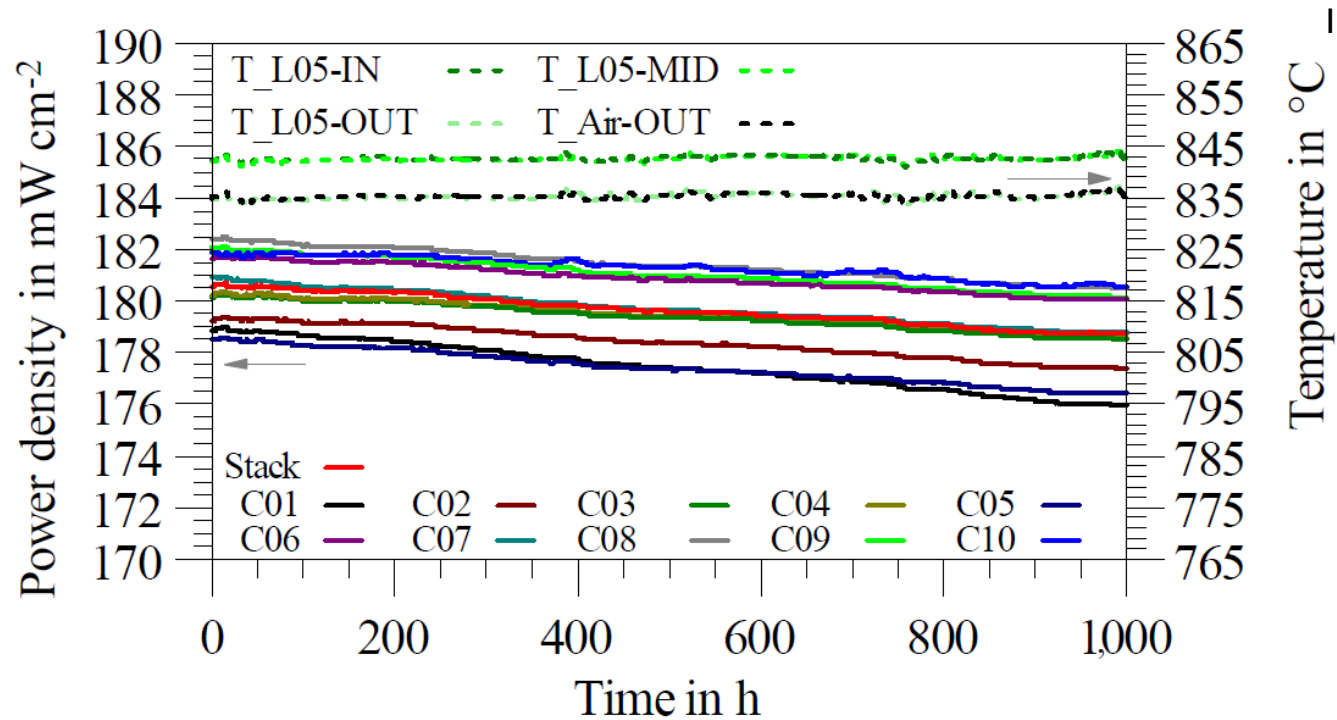
Stack from project partner



4. MK35x in ARENHA: Power generation from ammonia using SOFC

MK352 I0 cell stack in furnace: humidified ammonia (30% steam) in SOFC¹

- Long-term test: 1000 h
- FU: 80%
- $J=226 \text{ mA/cm}^2$
- $T_{\text{cat,o}}=835^\circ\text{C}$
 - $\Delta P/P_0=1.1 \text{ \%/1000 h}$
(comparable to $\text{H}_2\text{-N}_2$ -mixtures for first 1000 h)



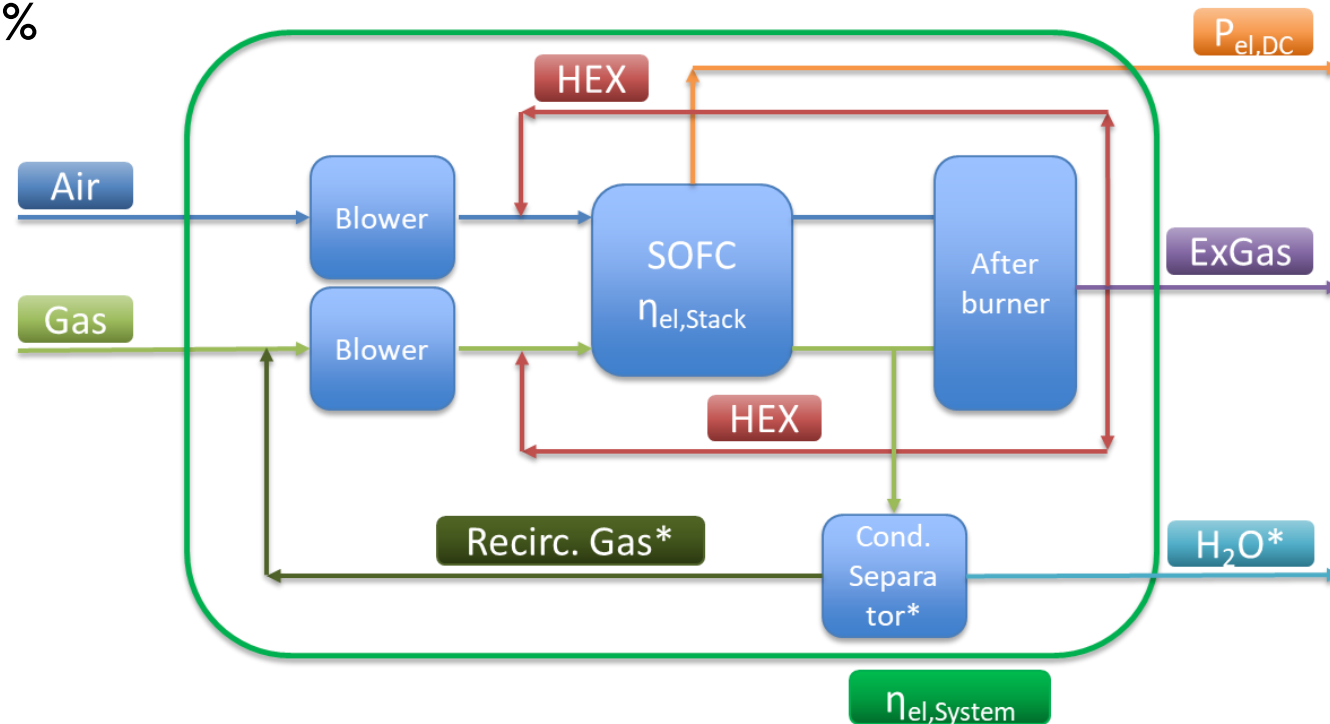
¹ B. Stöckl, V. Subotic, M. Preininger, S. Megel, Towards a wastewater energy recovery system: The utilization of humidified ammonia by a solid oxide fuel cell stack, Journal of Power Sources 450 (2020) 227608, <https://doi.org/10.1016/j.jpowsour.2019.227608>

4. MK35x in ARENHA: Power generation from ammonia using SOFC

Simulation in ASPEN: 40 cell stack

- Power output: 1 kW_{DC}
- 100 % ammonia; FU=75 %
- T=850°C
- CPOX, *AGR (70%)

- System efficiency:
 - CPOX: 46 %_{AC}
 - AGR: 56 %_{AC}



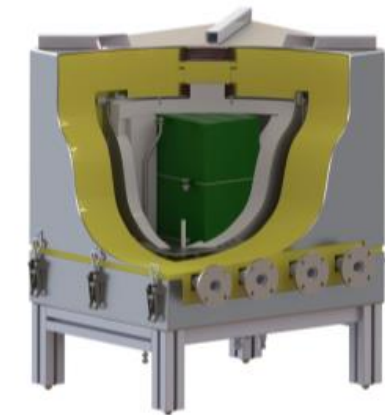


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5. Conclusion

- Proofed stack technology MK35x in ARENHA
 - Robust stacks suitable for power generation from ammonia and hydrogen generation
 - Power: SOFC: 20-40 W/cell depending on temperature and fuel
 - RedOx stability: $\Delta P/P_0 < 0.4\%$ / 10 cycles (75 cycles)
 - SOFC Degradation: $\Delta P/P_0_{(835^\circ\text{C})} = 0.7\%$ / 1000 h (>10.000 h, 40% H₂ in N₂)
 $\Delta P/P_0_{(835^\circ\text{C})} = 1.1\%$ / 1000 h (1.000 h, humidified ammonia)
 - SOFC system simulation with ammonia:
 - System efficiency: up to 56 %_{AC} with anode gas recycling





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Thank you for your attention

Website project: <https://arenha.eu/>

Contact: christian.eckart@ikts.fraunhofer.de