
CFY-stacks for use in stationary SOFC and SOEC applications

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3. SOFC system operation
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5. Conclusion



1. Introduction

Fuel cell development @Fraunhofer IKTS

Products and services along the complete value chain



1. Introduction

Intention

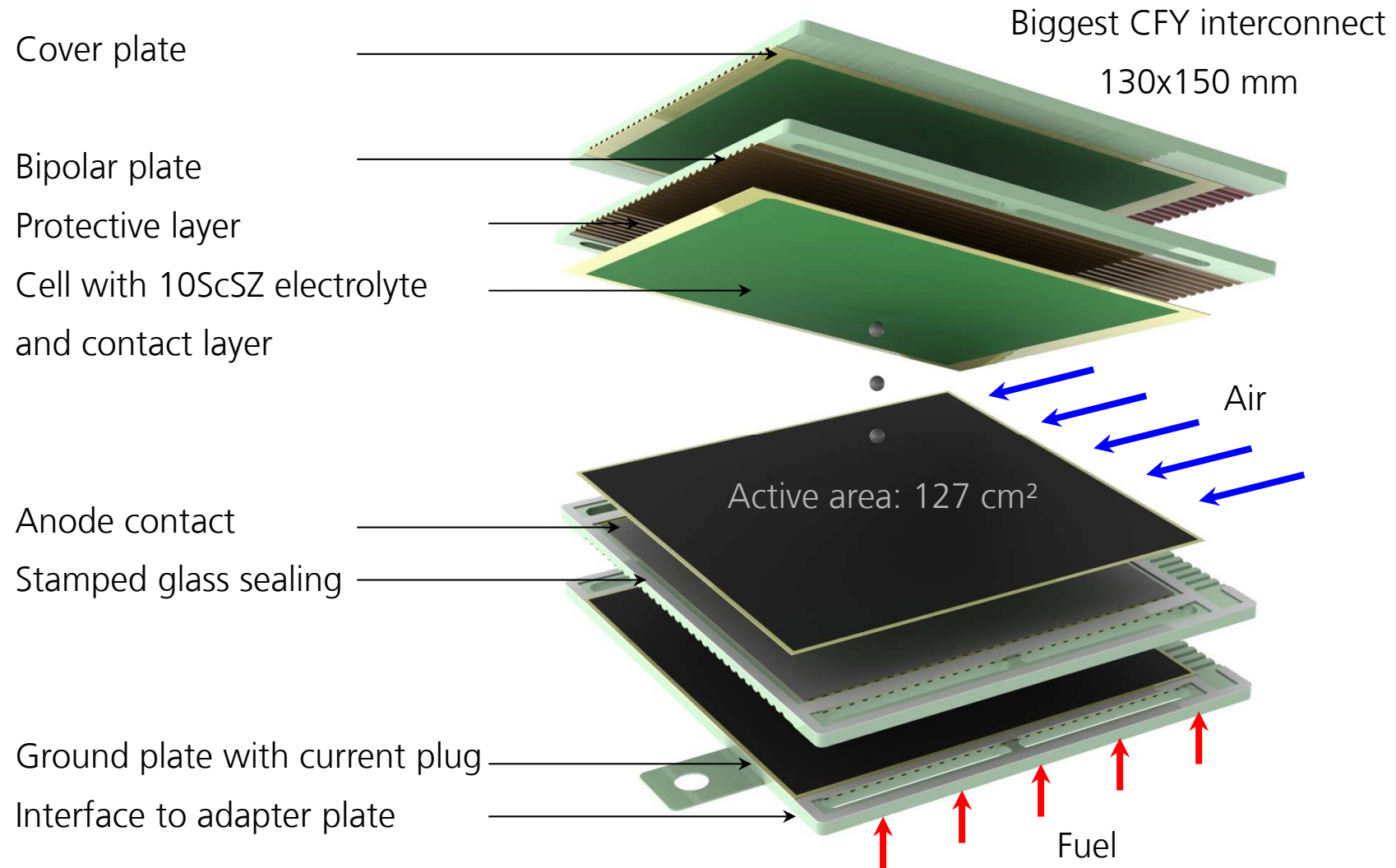
- SOFC stack modules of 1-200 kWel for decentralized power plants
- High electrical efficiency
- Low cost stacks with high reliability
- Suitable also for electrolysis of water



Core technology

- Near netshape interconnect: powder metallurgical processed and partially coated with protection layer
- High power density cells with 10ScSZ electrolytes (electrodes from Fraunhofer IKTS)
- CFY-Stack development >15 years

2.1 Stack assembly and integration



2.1 Stack assembly and integration

Stack assembly

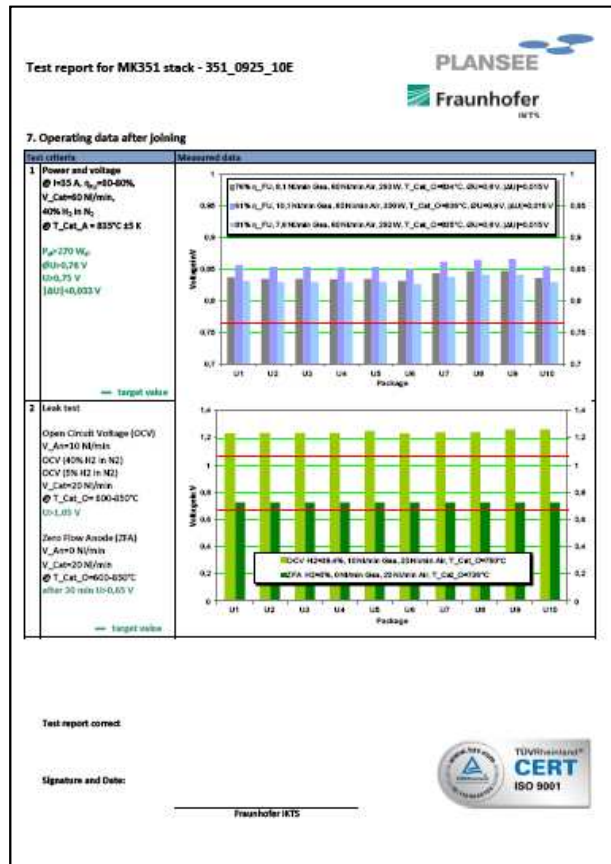


Sealing at a joining station



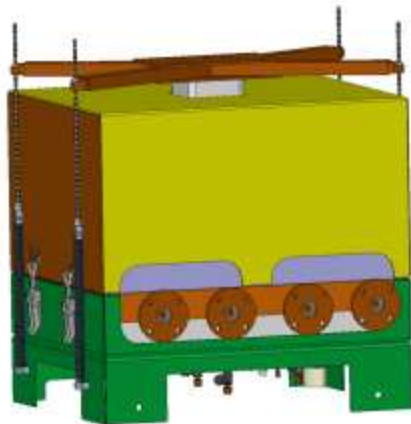
2.1 Stack assembly and integration

Stack certification report



2.1 Stack assembly and integration

30-cell stack in a hotbox



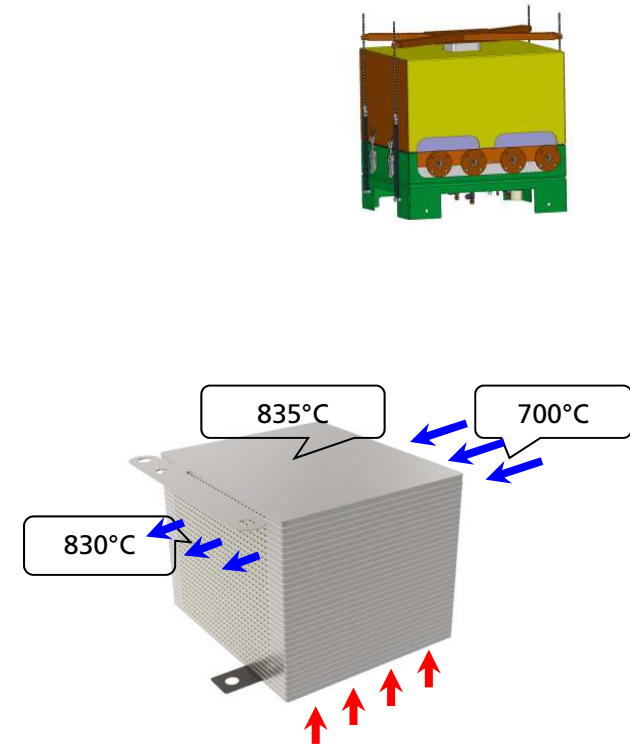
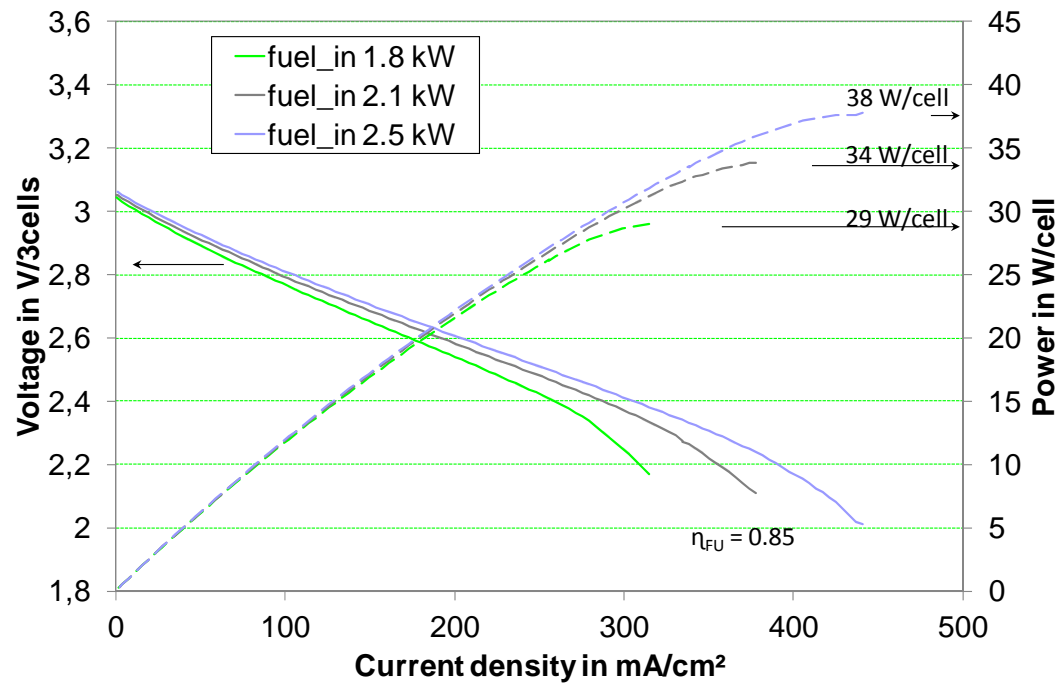
2.2 Stack power

30-cell stack in a hotbox: I-U-curve

Fuel: 40 % H₂ in 5% H₂O and N₂

Air: 100 sl/min

$T_{\text{Cat}_o} = 830^\circ\text{C}$



→ 20-50 W/cell

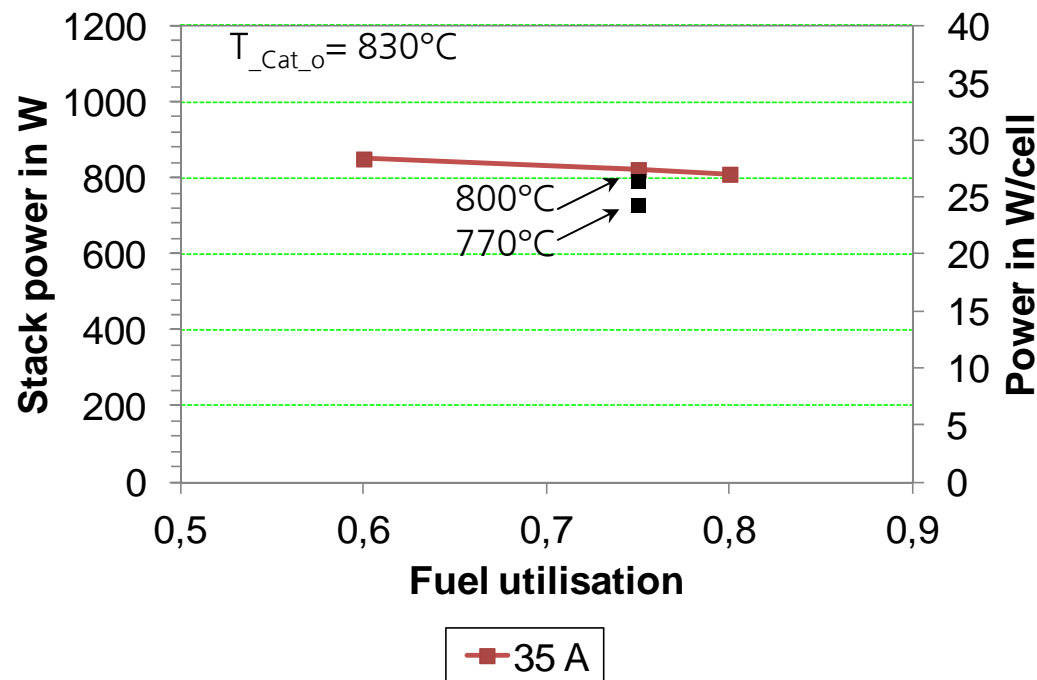
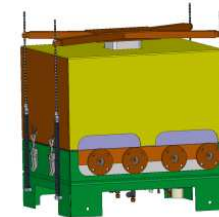
2.2 Stack power

30-cell stack in a hotbox: constant power point

Fuel: 40 % H₂ in 5% H₂O and N₂

Air: 100 sl/min

$T_{\text{Cat}_o}=830^{\circ}\text{C}$



→ Wide temperature range 750°C-900°C allows wide operation window

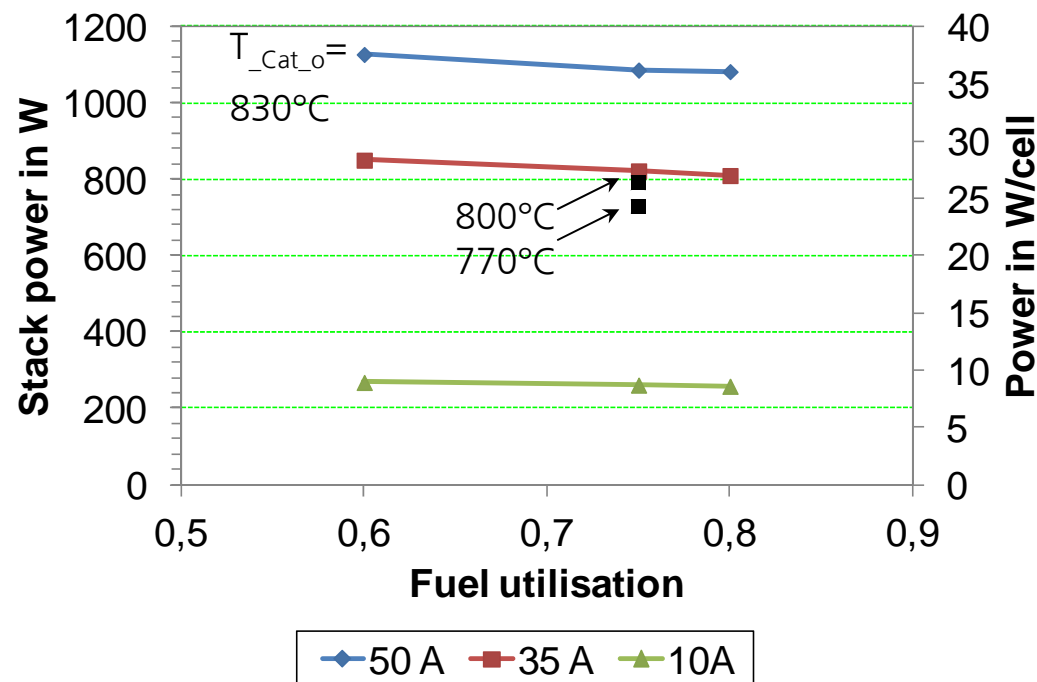
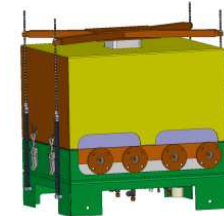
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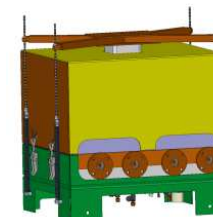
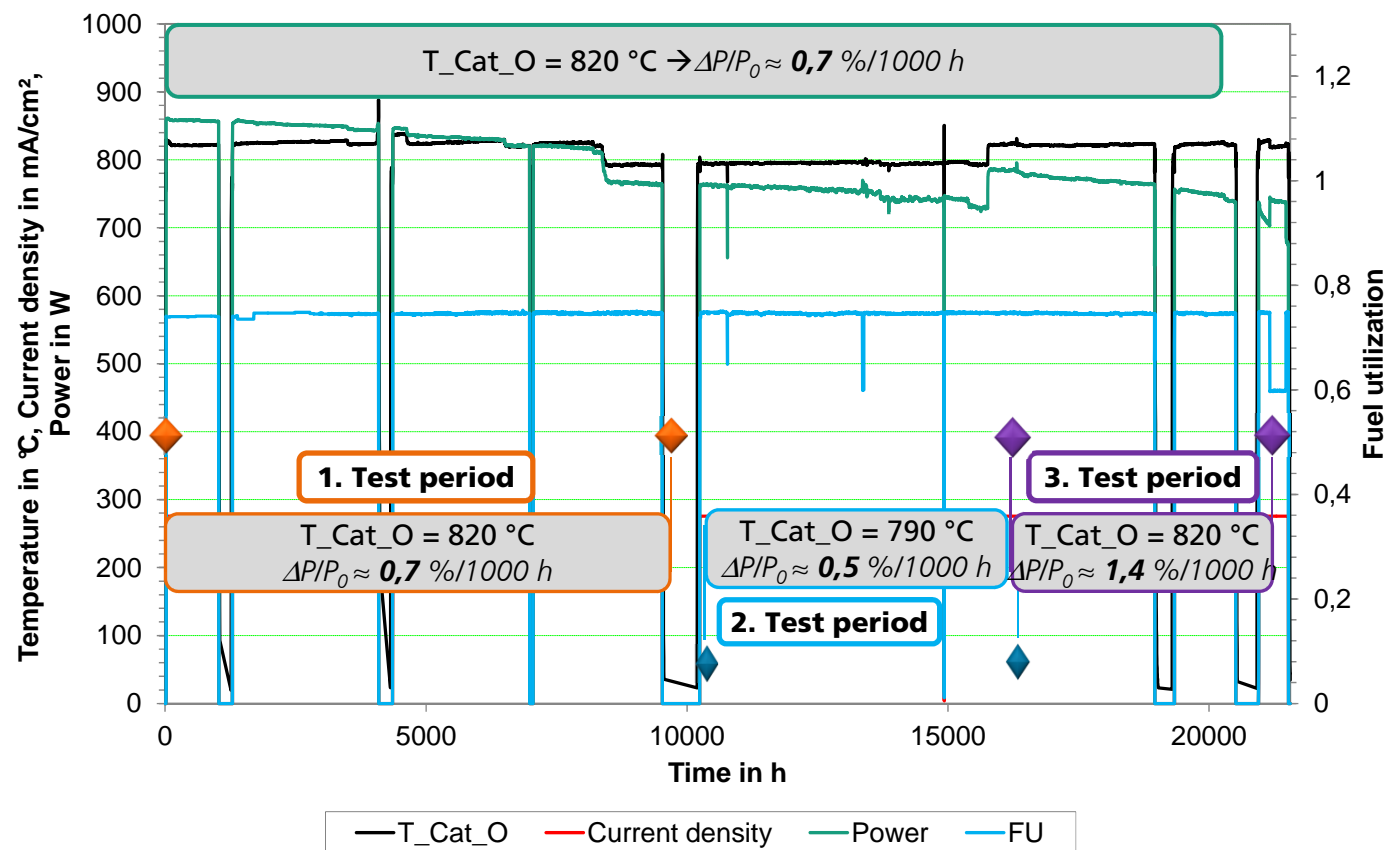
$T_{\text{Cat}_o}=830^{\circ}\text{C}$



- Possibility of part load for standby
- Wide temperature range 750°C-900°C allows wide operation window

2.3 Long-term stability

30-cell stack in a hotbox @35 A, fuel: 40% H₂ in N₂, air: 104 sl/min, $\eta_{FU}=75\%$

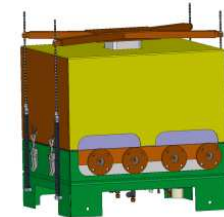
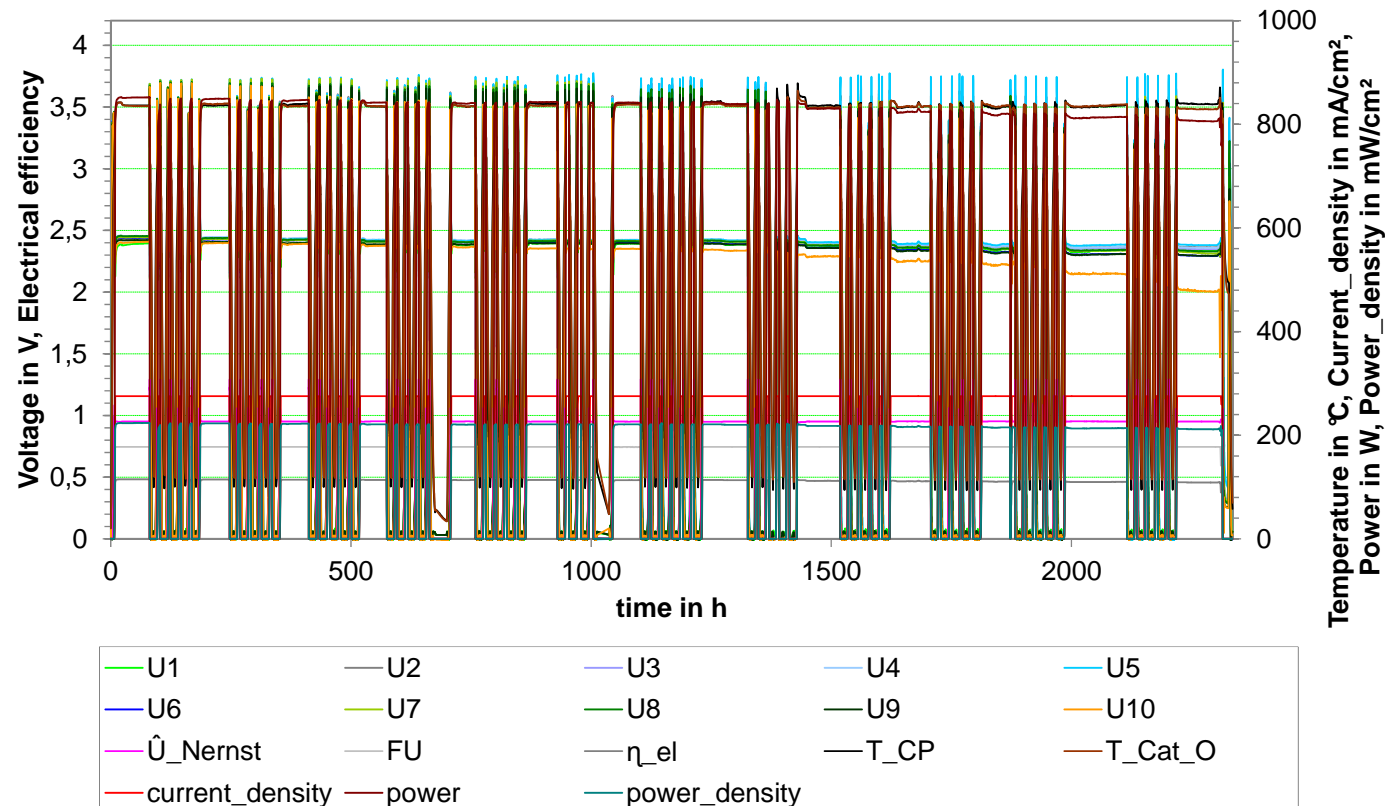


- $\Delta P/P_0 \approx 0.7\text{ \%/1.000 h}$ ($T_{Cat_O} = 820\text{ °C}$ >20.000 h)
- Similar degradation rate @ $T_{Cat_O} = 790\text{ °C}$ (>4500 h)

2.4. Start-Stop cycling ability

30-cell stack in a hotbox: cycling without gas at anode side (2-4 K/min)

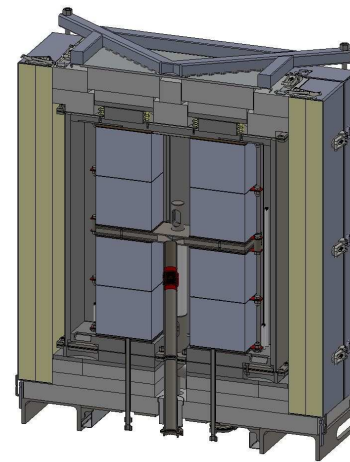
operation point: @35 A, fuel: 40% H₂ in N₂, air: 100 sl/min, $\eta_{FU}=75\%$



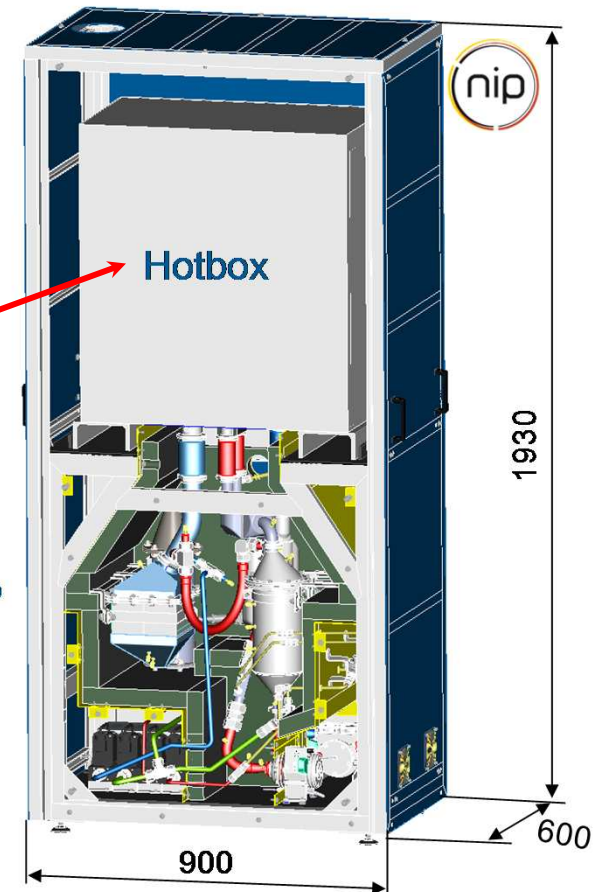
→ $\Delta P/P_0 = 852 \text{ W} - 811 \text{ W (60 thermal cycles)} = \mathbf{0.8 \% / 10 \text{ cycles}}$

3. SOFC system operation

8x30-cell stacks for SOFC20 system



BoP



System demonstrator @AVL with anode off-gas recycling

- $P_{el}=6.1 \text{ kW @ } 36.1 \text{ A, } T_{max}=850^{\circ}\text{C}$
- $\eta_{el_DC}>50\%$
- $>900 \text{ h operation}$

PLANSEE

SCHOTT
glass made of ideas

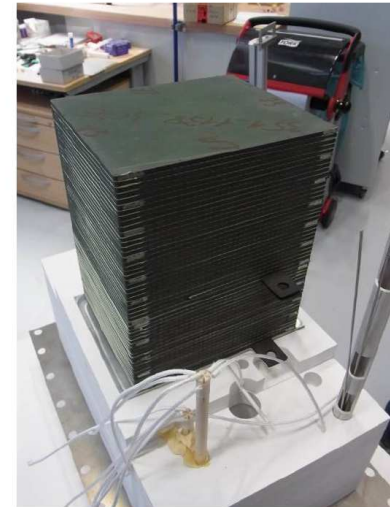
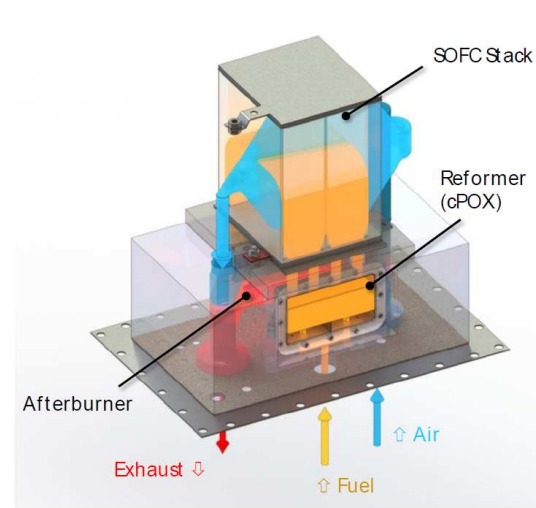


JÜLICH
FORSCHUNGSZENTRUM

3. SOFC system operation

SOFC/Battery-Hybrid System for Distributed Power Generation in India

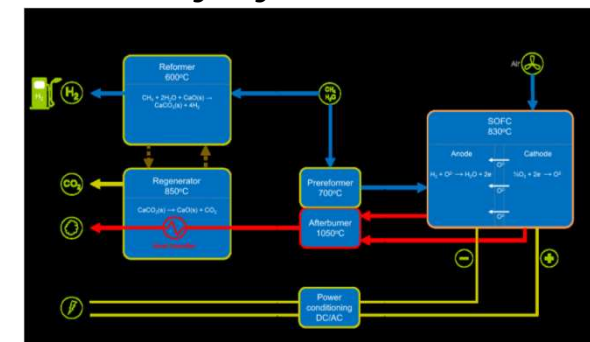
Thomas Pfeifer et. al., 11th EFCF, A1210, Luzern 2014



Mobile power supply by NewEnergyday



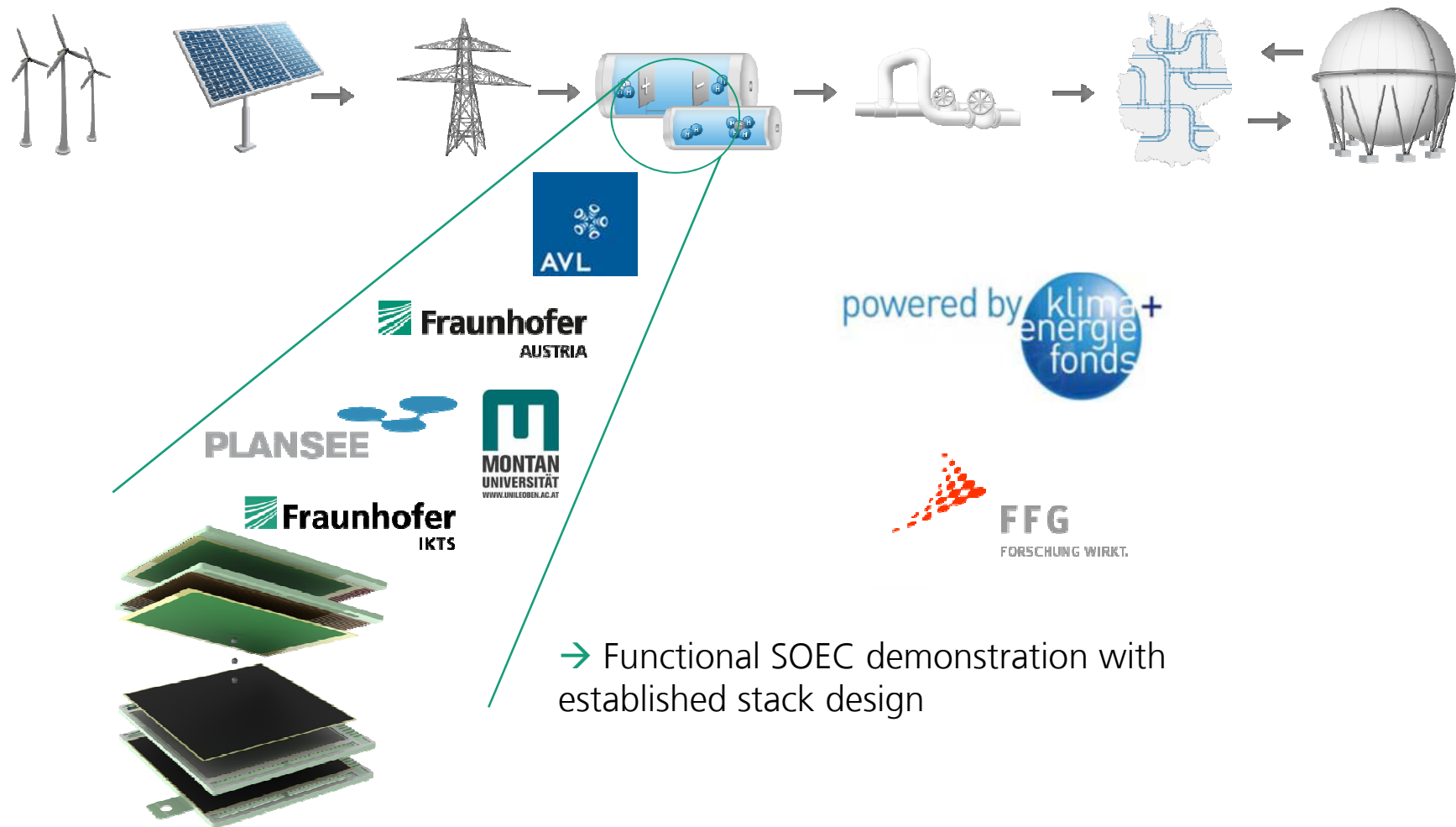
Production of Hydrogen and Electricity by ZEG-Power



Arnstein Norheim et. al., 11th EFCF, A1208, Luzern 2014

4. SOEC operation

"HydroCell" - Project

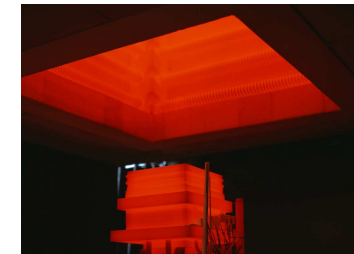
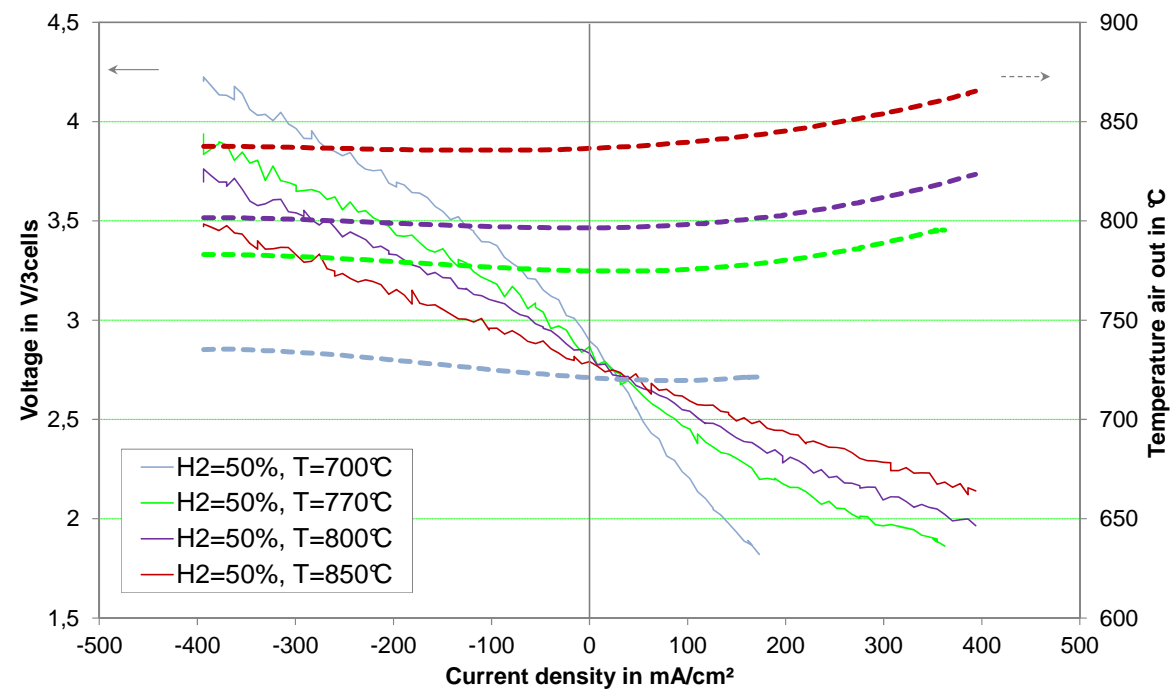


4. SOEC operation

30-cell stack in Oven: U-I curve

Gas: 50 % H₂ in 50% H₂O

Air: 100 sl/min $T_{\text{Oven}}, T_{\text{gas}_i}, T_{\text{air}_i} = T = \text{constant}$



→ Stable behavior at SOEC operation 700-850°C

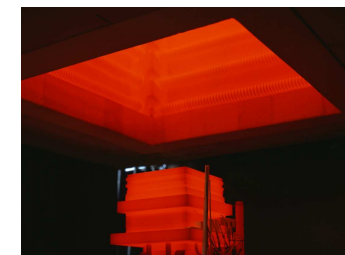
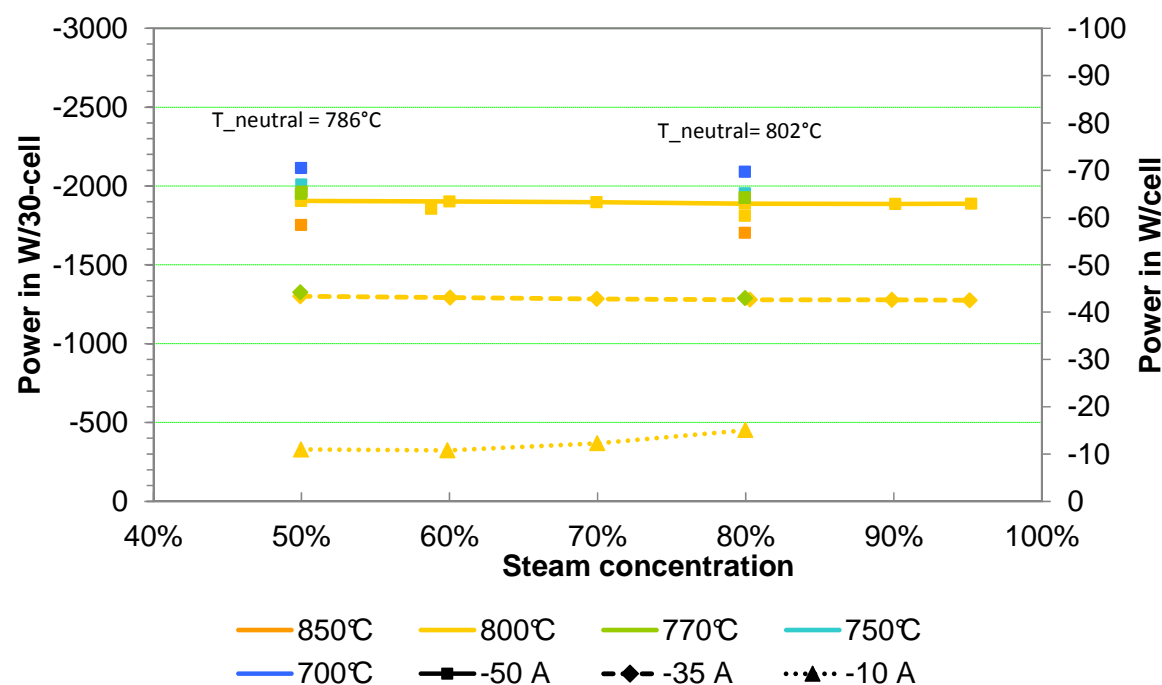
4. SOEC operation

30-cell stack in Oven: Performance Map

Gas: H₂ in H₂O

Air: 100 sl/min

$T_{\text{Oven}}, T_{\text{gas}_i}, T_{\text{air}_i} = T = \text{constant}$



-50 A $\eta_{\text{FU}}=75\%$ 50 %H ₂ in H ₂ O	
T in °C	P _{el} in W
850	-1760
800	-1870
770	-1950
700	-2120

→ Stable behavior at SOEC operation 700-850°C

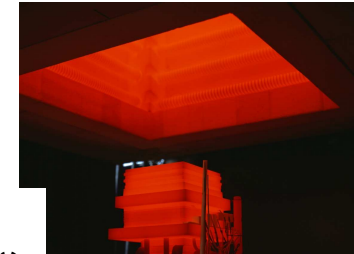
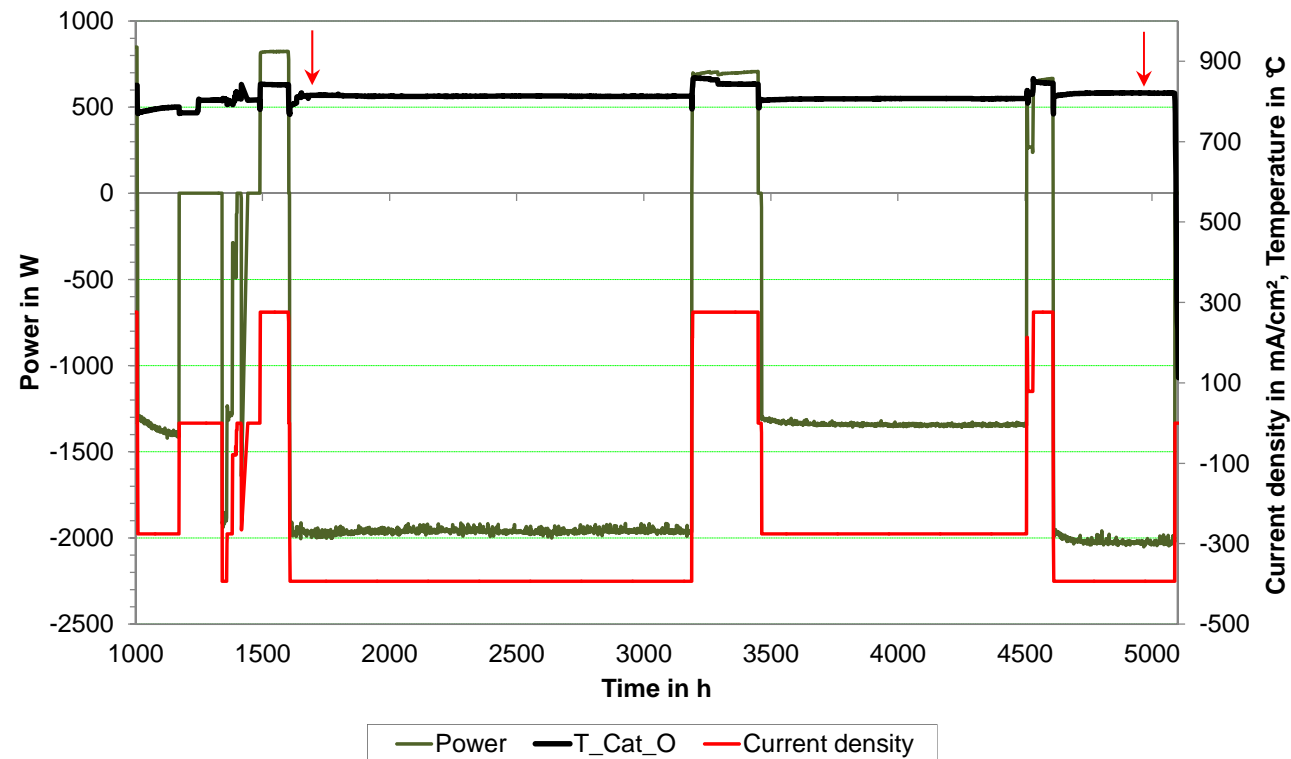
→ Thermoneutral operation at 800°C

4. SOEC operation

30-cell stack in Oven:

Gas: 20 % H₂ in 80% H₂O $\eta_{FU}=75\%$

Air: 100 sl/min $T_{Oven}, T_{gas_i}, T_{air_i} = T = 800^{\circ}\text{C}$



→ $\Delta P/P_0 = -0,8\%/1000\text{ h}$

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Thank you for your attention!

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Thanks to my colleagues at
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www.ikts.fraunhofer.de

