Introduction

Solid oxide cells (SOC) exhibit the unique feature to be able to run in reversible operation and the capability to run with hydrocarbons. Due to the high temperature of the process, solid oxide cells exhibit very high efficiency in steam electrolysis and co-electrolysis mode (H_2O+CO_2). This makes it very attractive for Power-to-X. At the German Aerospace Center, SOCs are investigated from cell to stack level in order to characterize and understand the degradation behaviour (Fig.1 and Fig.2), identify an appropriate operation strategy and propose alternative materials to mitigate degradation issues.

At the system level the coupling of the high temperature electrolysis process with heat from a concentrated solar power plant is investigated in order to achieve very high efficiency (Fig.3 and Fig.4). In the frame of the DLR project „Future Fuels“ the combination of a steam receiver powered by heat from a solar simulator with a solid oxide electrolyzer stack has been realized for the first time.

Within a recently started project with AUDI AG, Germany, DLR works on the investigation of SOC stacks under near-system operating conditions in electrolysis as well as reversible operating mode. The electrochemical performance will be monitored during long-term tests to be compared with identical stacks implemented in an industrial reversible SOC system. The concept of the power-to-gas plant with 300 kW power is presented (Fig.5 and Fig.6); experimental results will be published later.

Reversible SOC for power-to-gas

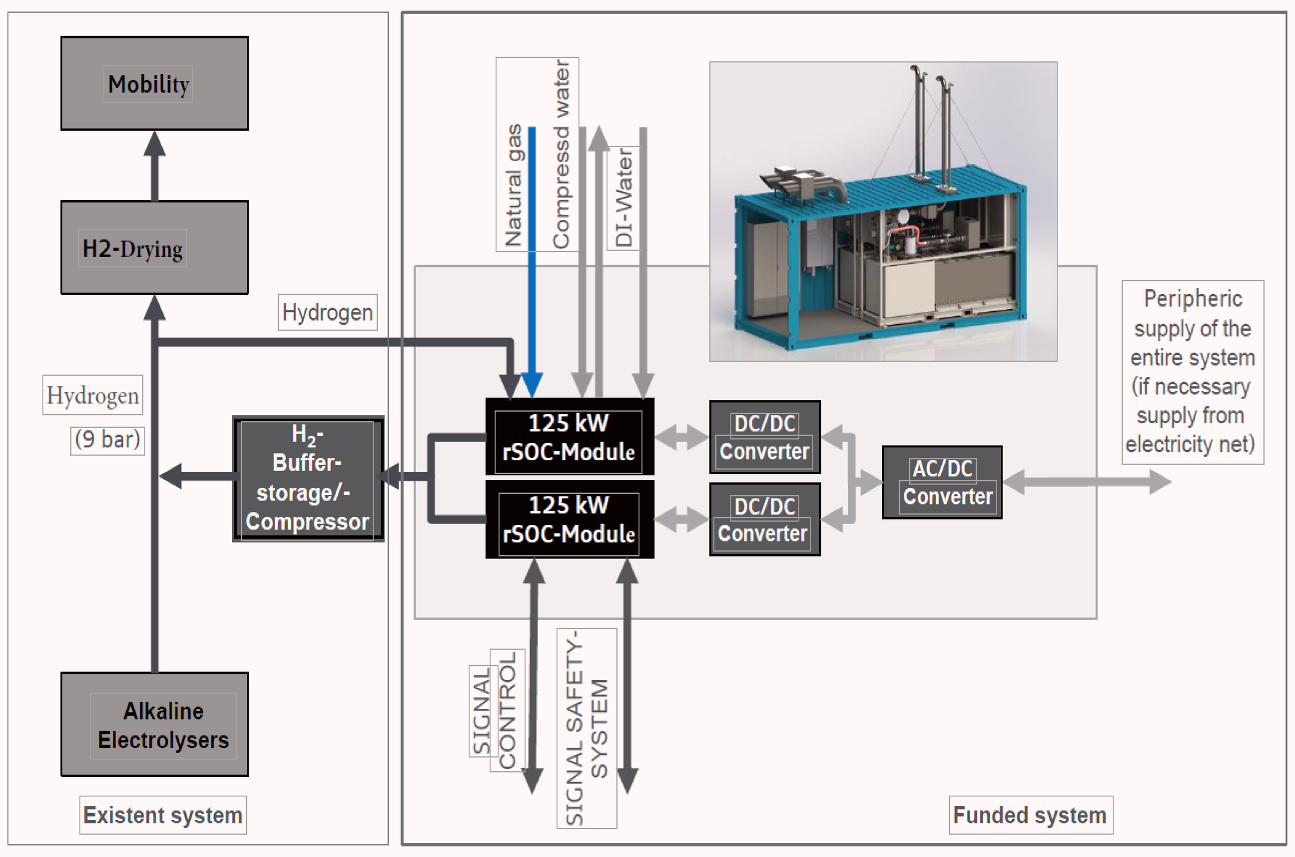
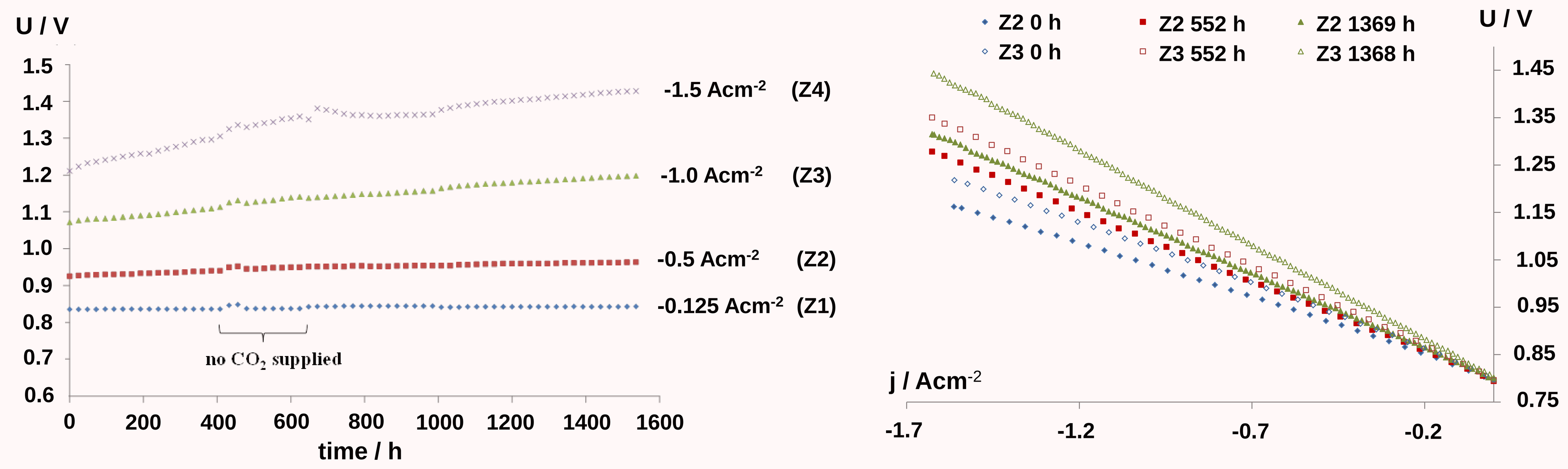


Fig. 5: System layout of planned rSOC power-to gas plant in Werlte, Germany

Fig. 6: Photograph of existing Audi e-gas plant in Werlte, Germany

Co-electrolysis operation



1536 h Test	Z1	Z2	Z3	Z4
ΔV (mV/1000 h)	5.2	24.7	82	141
%/1000 h	0.6	2.7	7.7	11.7

Fig.1: Long-term test (left) of SOEC single cell over 1500 h at 800 °C at 4 current densities (-0.125, -0.5, -1.0, -1.5 Acm^{-2}) and jV-curves (right) after 0 h, 552 h and 1368 h (fuel: 57% H_2O, 36% CO_2, 7% H_2)

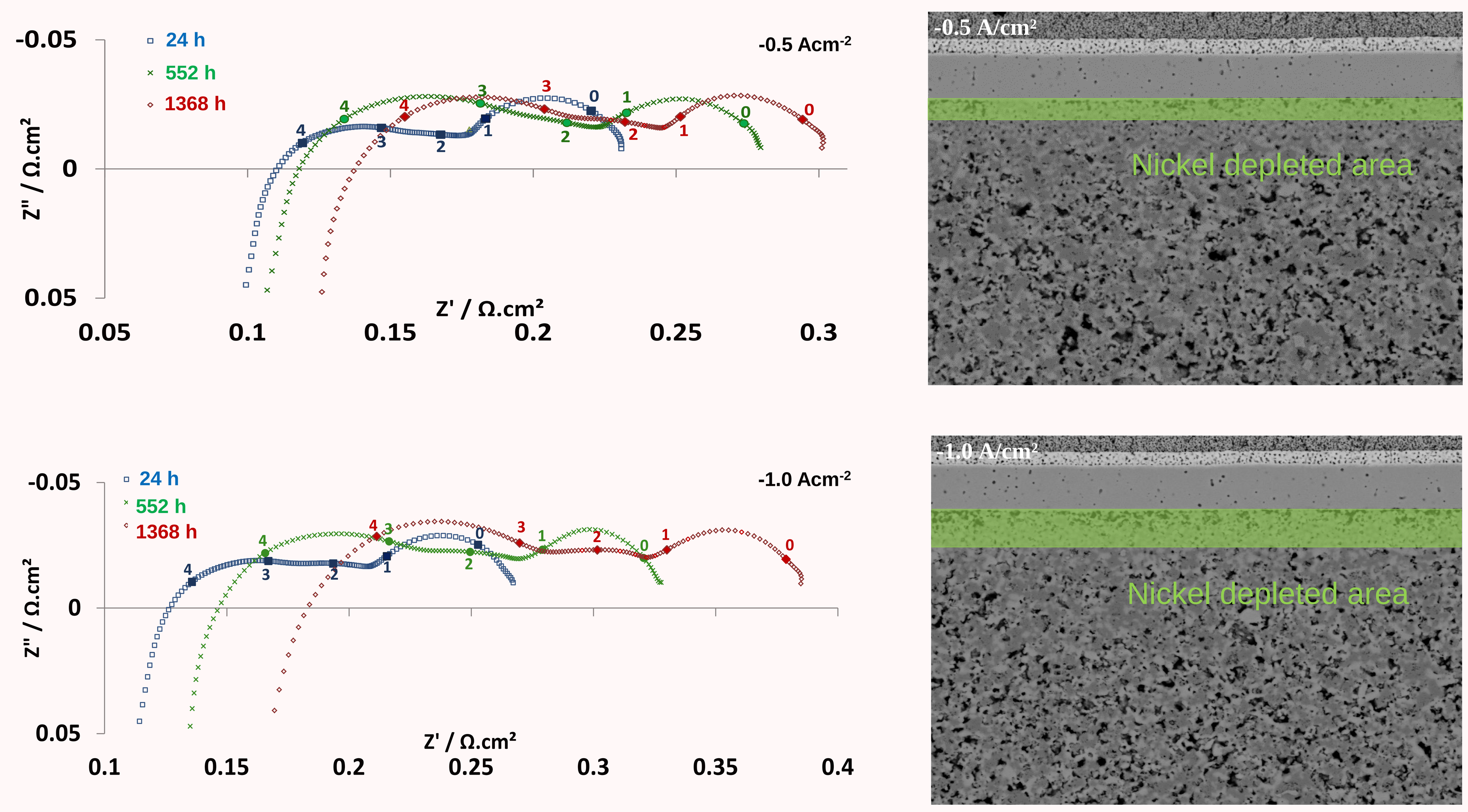


Fig.2: Impedance spectra (left) of SOEC single cell at -0.5 and -1.0 Acm^{-2} after 24 h, 552 h and 1368 h and SEM images (right) after operation at -0.5 and -1.0 Acm^{-2} (area with nickel depletion is highlighted in green)

Solar heat integrated steam electrolysis

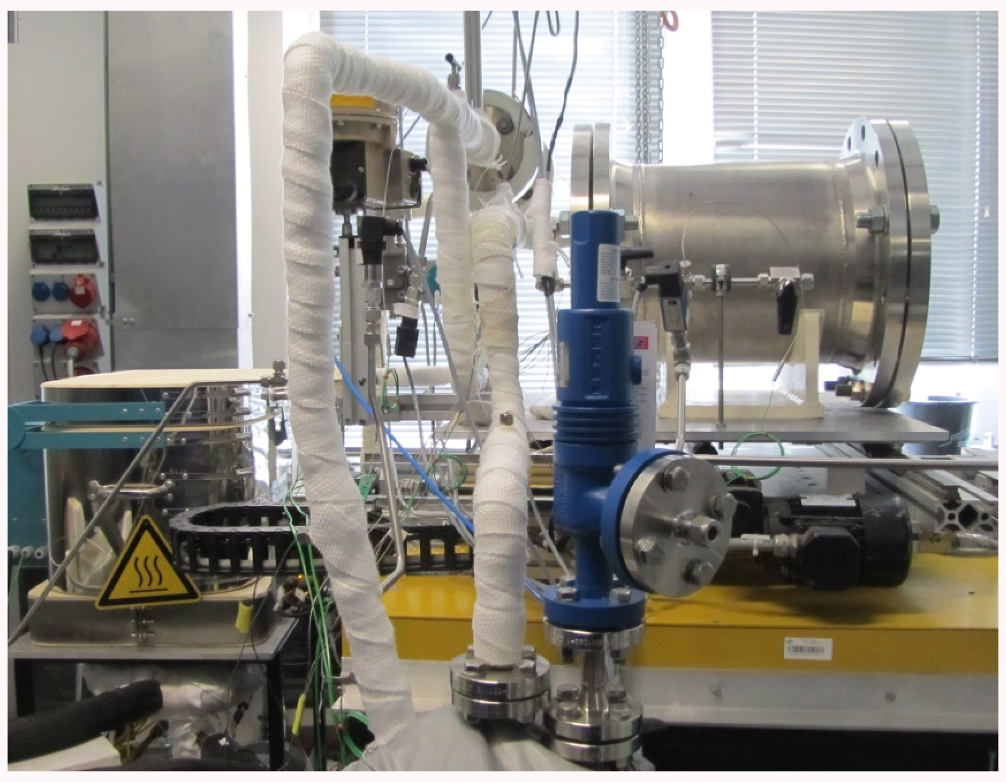


Fig. 3: Photograph of system with SOEC stack from SolidPower (left) and solar receiver (right)

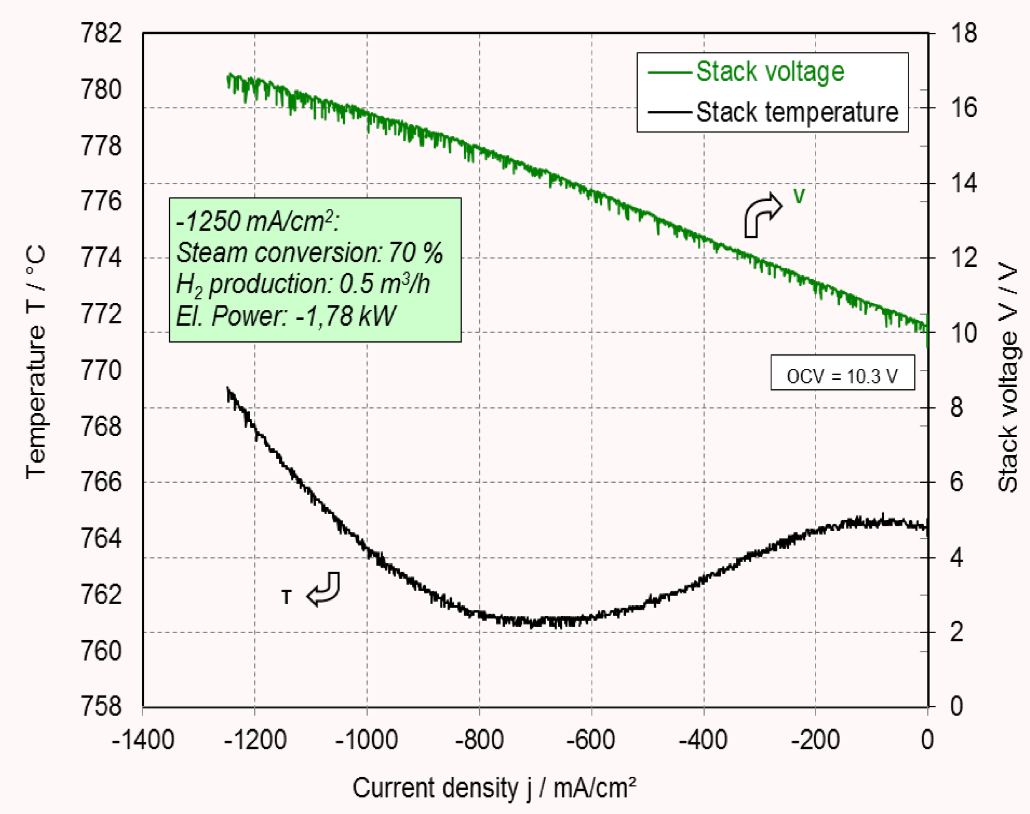


Fig. 4: jV-curve of a 12-cell SOEC stack at 765 °C with steam generated by a high flux solar simulator

References

R. Costa, F. Han, M. Hoerlein, M. Lang, N. Sata, G. Schiller, K.A. Friedrich, ECS Transactions, 85, 1-11 (2018)

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