



## Solid Oxide Cell Systems & Their Role in the Energy System

R.J. Braun, A. Parashar, O.B. Rizvandi, G. Floerchinger, A. Ashar, S. Conley  
Colorado School of Mines, Department of Mechanical Engineering, Golden, Colorado, USA

[rbbraun@mines.edu](mailto:rbbraun@mines.edu)

**Keywords:** solid oxide, reversible fuel cells, electrolysis, power-to-x

High temperature solid oxide electrochemical stack and system technologies are rapidly scaling from kW to MW levels. Much of the development efforts are driven by the need for scalable, low-cost, high-efficiency energy delivery solutions for either hydrogen or power production. This presentation will highlight advancements and opportunities in distributed and large-scale power generation using solid oxide fuel cells (SOFCs), the potential of reversible SOC technology for grid-balancing and flexible hydrogen production, and the use of co-electrolysis via solid oxide electrolysis (SOEC) technology for liquid fuels production (Fig. 1).

In particular, the large increases in stationary electric power demand expected for hyperscale and colocation data centers, expanding energy sector electrification, and the need to decarbonize marine transportation is motivating continued SOFC development. The low-emission, fuel-flexible, high-efficiency characteristics of SOFCs have long positioned the technology as an attractive alternative to diesel or combustion turbine generators. As SOFC technology approaches wider-scale deployment of MW-scale systems, greater precision in model-based design and simulation of high temperature integrated energy systems is needed to help accelerate industrial scale-up efforts. This presentation will highlight multi-stack scale-up considerations and their impact on system-level power generation performance.

Reversible solid oxide systems can operate in both electrolysis and fuel cell modes, enabling the flexible production of hydrogen and electricity in future low-carbon energy systems. Thermodynamic and techno-economic metrics are assessed using both historical and forward-looking electricity price data to quantify the operational value of flexibility under evolving grid conditions. The results highlight the influence of balance-of-plant design, thermal integration (e.g., the impact of ‘free’ heat), and electricity price variability on system performance. These findings offer guidance for designing and operating reversible solid oxide systems for deployment in dynamic electricity markets and industrial settings.

Lastly, renewable methanol (MeOH) production is essential for decarbonizing fuels and chemical feedstocks, but its economic competitiveness remains challenging. This work investigates SOEC-based liquid fuel production as a potentially superior alternative to conventional syngas production routes within Power-to-X systems. SOECs were selected due to their high electrical efficiency specifically for syngas ( $H_2$  /CO) production and their unique capability for direct co-electrolysis. This feature enables the generation of tailored syngas ratios, simplifying downstream processes compared to methods requiring separate hydrogen production, and conditioning. The techno-economic feasibility of a novel 100 MWe SOEC-integrated process plant that couples SOEC co electrolysis with reverse water gas shift and high conversion methanol reactors was designed and evaluated. Expected process efficiency and liquid fuel production costs are presented.

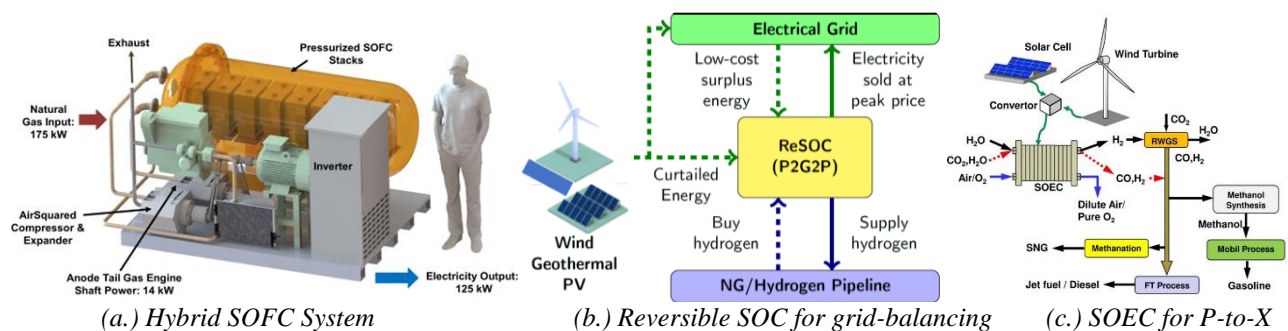


Figure 1: Solid oxide electrochemical technology solutions for various energy delivery applications



FDFC 2026

5-7 May 2026  
Montpellier - France

**Acknowledgements.** The authors would like to thank the U.S. Department of Energy ARPA-E, Office of Naval Research, and former Hydrogen & Fuel Cells Technology Office for funding.