Support U.S. DOE NETL goal of Advancing SOFC component/system technologies as needed to demonstrate sustainable performance of a ≥10-MWe SOFC system integrated with carbon capture, utilization, and storage (CCUS).
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SOFCtc OVERVIEW

Gasifier Options Include:
- Pressurized Fluid Bed (PFB)
- Entrained Flow
- Downdraft Fixed Bed

Coal

Steam/Air or Oxygen

PFB Gasifier 1450 - 1750°F

Syngas Cleanup Train*

Syngas Bottle Fill Station < 3300 psig

Syngas Dryer <450 °F

Bypass

Syngas Compressor 3200 psig

Syngas Storage Tank 90 °F

Syngas Delivery Manifold < 200 psig

Gas Delivery Manifold** < 200 psig

NG Sulfur Capture Station 100 °F

Synthesis Gas Storage Tanks 90 °F

Natural Gas

EERC Test Stand Up to six cells or stacks, up to 38 cm³/cell

Horiba Test Stand Cell or stack, up to 100 cm³/cell, up to 1 kW total output

Fiaxell Test Stand Cell or stack, up to 100 cm³/cell

Gas Cylinders (N₂, H₂, CO, CO₂, CH₄) and Contaminants

*Syngas Cleanup Train

Particulate Filter 700 °F

CO Shift Reactor 650 °F

Regenerable Sulfur Removal 650 °F

Polishing Sulfur Removal 450 - 500 °F

Fixed Bed Trace Metal Removal 450 - 500 °F

Gas Cooling/Quench for H₂O, H₂O Solubles, Tar Removal 60 - 70 °F

CO₂ Scrubber 50 - 60 °F

To Syngas Dryer

** Gas Delivery Manifold: Includes capability for simultaneous delivery of different fuels to different test stands.
Syngas (CO + H₂) Production
H₂ Production and Purification
Gas Blending and/or Contaminant Addition
SOFC System and/or Component Testing

- Renewable Methane
- Natural Gas
- Coal
- Biomass
- Waste
- Water + Electricity
- CO₂ + Water + Electricity
- Hydrogen

Reforming → Gasification → Electrolysis → Syngas and/or H₂ → Button Cell(s) → Planar Cell(s) → Tubular Cell(s) → Stack(s)

- Performance and Durability Testing
- Hours/Weeks/Months
- Up to 1 kW Total Output
SIMULTANEOUS OPERATION
MULTIPLE TEST STANDS WITH MULTIPLE FUELS

Desulfurized Natural Gas or Methane
Clean Syngas
Gas Cylinders (N₂, H₂, CO, CO₂, CH₄) and Contaminants

Manifold for Gas Metering

Fuel A
Fuel B
Fuel C

Fuel A, B, or C
Fuel A, B, or C
Fuel A, B, or C

EERC Test Stand
Up to six cells or stacks, up to 38 cm²/cell

Horiba Test Stand
Cell or stack, up to 100 cm²/cell, up to 1 kW total output

Fiaxell Test Stand
Cell or stack, up to 100 cm²/cell
WHAT DO YOU WANT TO LEARN?

- Cell performance and degradation with complex or contaminant-bearing fuels
- Impact of exhaust recycle on SOFC performance
- System integration strategies
  - Thermal integration
  - Carbon capture
- Impact of CO oxidation/H$_2$ oxidation ratio on SOFC voltage
SYNGAS STORAGE AND DELIVERY

- Storage tank capacity:
  - 20,900 scf at 2600 psi
- Fuel options:
  - Syngas from EERC gasifier (coal, biomass, waste, blend of these)
  - Natural gas (desulfurized)
  - Bottled gas (single or blends of $\text{H}_2$, $\text{CO}$, $\text{CH}_4$, $\text{CO}_2$, $\text{N}_2$, other)
  - Added contaminants
- All three SOFC test stands can be operated simultaneously with up to four different fuels (EERC test stand can accommodate two separate fuels).
HORIBA TEST STAND

Features

• Up to 1-kW cell or stack capacity
• Furnace dimensions:
  – Length: 10 inches
  – Width: 10 inches
  – Height: 10 inches
• Class 1, Division 2, Group 2 enclosure
• Fully automated system
• On-site and remote monitoring
• Fuel supply and exit sampling ports
• Maximum temperature: 1100°C
EERC TEST STAND

Features

• Accommodates up to six cells/stacks and two unique fuel specifications simultaneously
• Furnace dimensions:
  - Diameter: 15 inches
  - Height: 13 inches
• Fully automated system
• On-site and remote monitoring
• Fuel supply and exit sampling ports
• Maximum temperature: 1100°C
FIAXELL TEST STAND

Features

• Accommodates a single cell or stack up to 100 cm$^2$
• Furnace dimensions:
  - Length: 8 inches
  - Width: 8 inches
  - Height: 8 inches
• On-site and remote monitoring
• Maximum temperature: 1000°C
PERFORMANCE ANALYSIS CAPABILITIES

• Potentiostats
  – Six-channel, Autolab
  – Eight-channel, Solartron Analytical
• Direct current loads
  – Five-channel load, zero-volt, 15-amp/channel (quantity two)
  – Single-channel load, 1.5–150 V, 0–200 A, 1 kW
• Current–voltage (IV) tests
• Electrochemical impedance testing (EIS)
• Voltage/current hold tests
• Partial pressure testing for any gas element, anode and cathode side
• Fuel supply and exit gas analysis
  – GC–MS, LGA, FTIR, Dräger tubes
• Imaging, pre- and postmortem imaging of cell components
COLLABORATE WITH THE EERC SOFCtc

- Call us!
- Defining test objectives, desired outcomes
- Assist in designing a test plan
- Consider adaptation of existing or addition of new hardware
- Establish cost and explore possible collaborative funding options
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THANK YOU
Critical Challenges. Practical Solutions.