Overview of SOFC Program at DOE NETL

NATIONAL ENERGY TECHNOLOGY LABORATORY

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Preface

This presentation provides an overview of a Fossil Energy and Carbon Management (FECM) R&D Program that is implemented based on both Administration priorities and Congressional direction. Plans for future technology development reflect expected trajectories of current R&D, but these plans are subject to change. Furthermore, some stages of future technology development, although necessary for commercialization, may not be financially supported by the government.

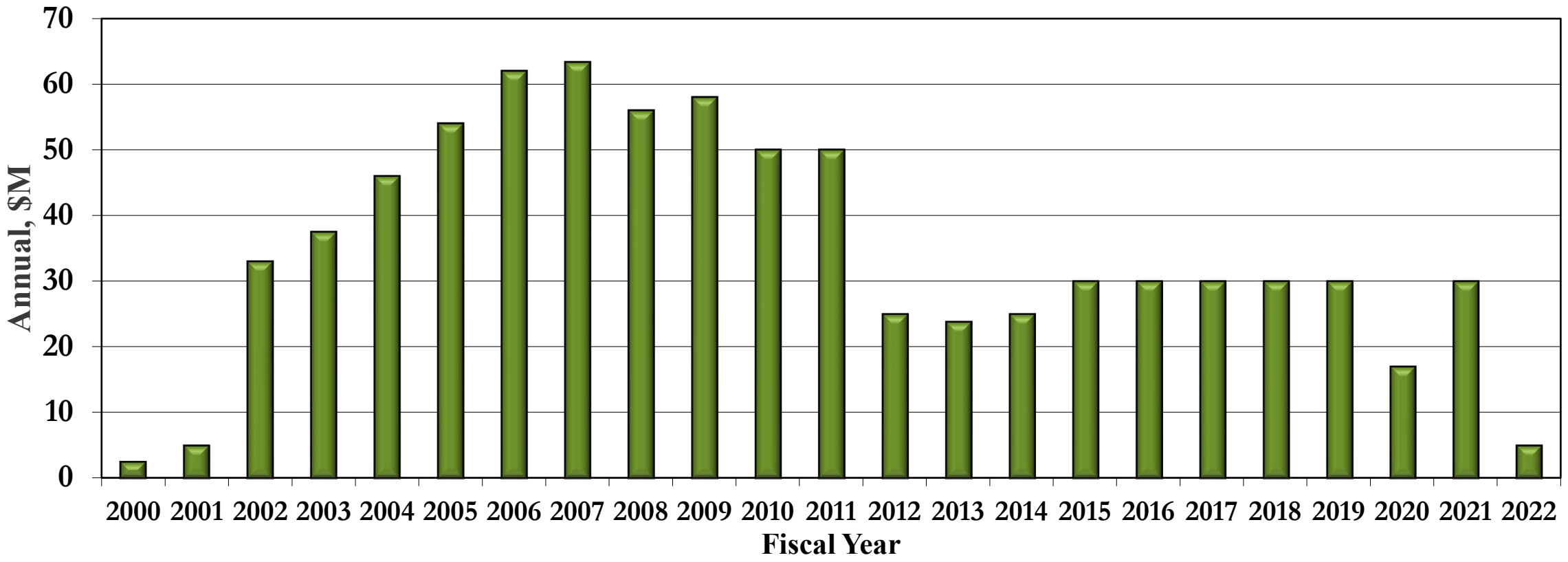
SOFC Program: Near-Term Objectives

Validate small-scale SOFC systems for distributed generation applications

Develop efficient and cost-effective electrolyzers (SOEC) for hydrogen production

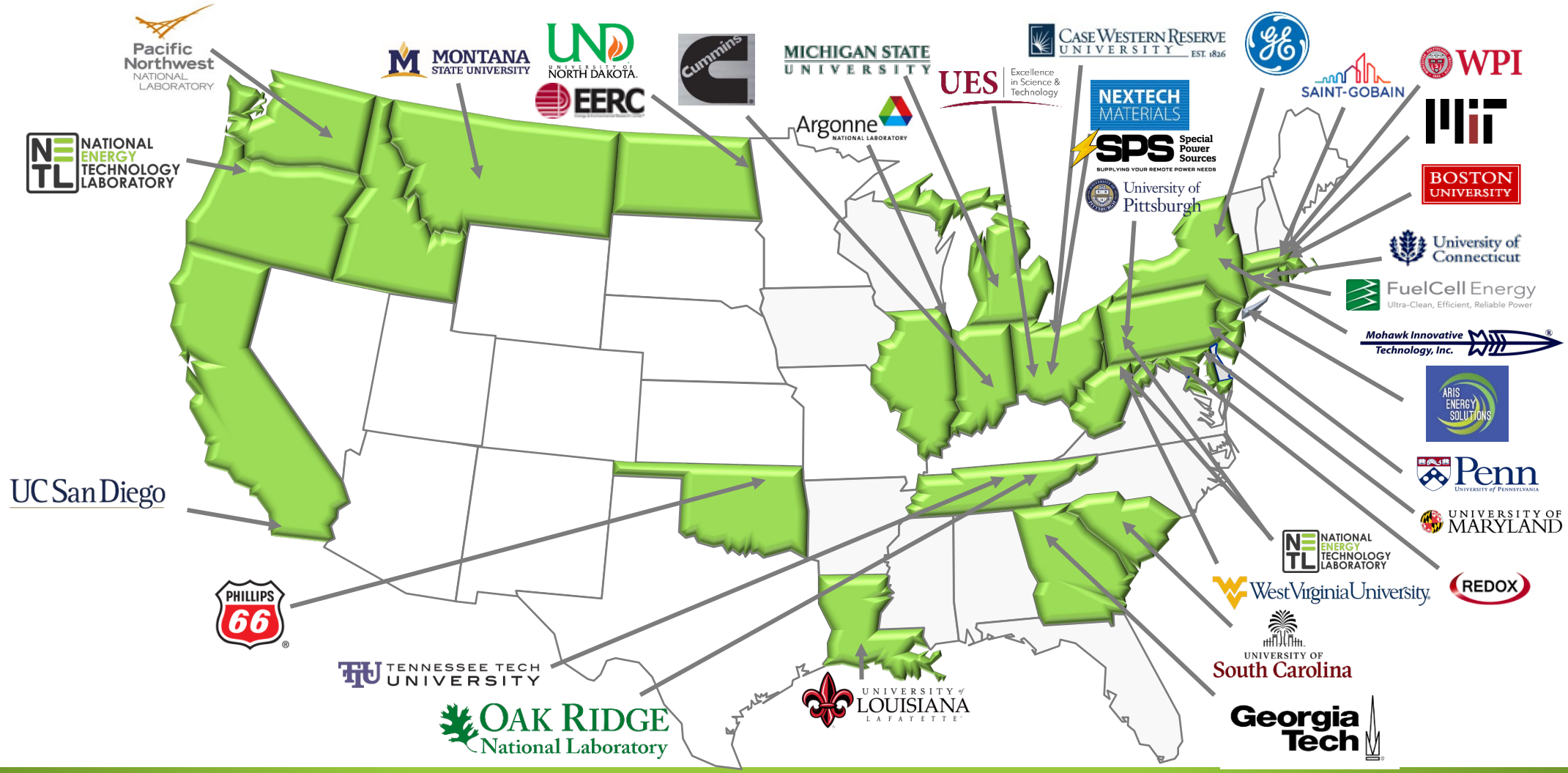
Conduct R&D to mature SOFC and SOEC technologies and make progress towards low cost, high efficiency hydrogen production and power generation

SOFC Program: Funding History



SOFC Program Project Portfolio

FY22 Participants



SOFC R&D at NETL Research and Inovation Center (RIC)

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Cell and Stack Degradation Modeling

- Development of comprehensive predictive modeling tool
- Atoms to system scale bridging
- Validation through experiment

Electrode Engineering

- Mitigation of prominent degradation modes
- Successful transfer of technology to industry

Systems Engineering and Analysis

- Public dissemination of SOFC market potential, performance, and cost advantages
- Hybrid configuration assessment
- Tie to R&D goals and objectives

High Temp Optical Sensors

- Multi-application technology under development for high temperature sensing
- Demonstrated in SOFC
- In-situ sensing of temperature distribution and gas composition

NETL RIC Accomplishments

Cell and Stack Degradation Modeling

- **Added to degradation modeling framework:**
  - Infiltrated materials
  - Reversible SOFC operation
  - Delamination/cracking
  - Redox/thermal cycling

Created microstructural analysis tool for analyzing 3D electrode reconstructions

Developed machine learning methods for predicting lifetime performance from microstructural data

Electrode Engineering

- **Tested commercial SOFC in reversible mode**
- **Infiltrated commercial SOFC showed significant reduction in degradation when operating under electrolysis mode**
- **Novel materials discovery and fabrication**
- **Used addictive manufacturing to produce cathodes with microstructural gradients in three dimensions**

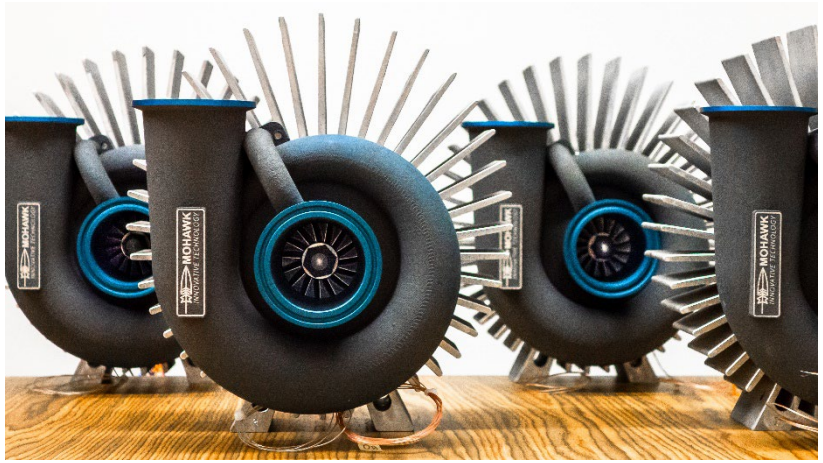
Systems Engineering and Analysis

- **Robust cell and stack production cost model completed**
- **Updated IGFC and NGFC techno-economic analyses**
- **Scoping study completed on hybrid carbon conversion technologies with SOFC component**
  - Collaboration with INL

SOFC Accomplishments

Mohawk Innovative Technology

- **High temperature Anode Exhaust Recycle Blower tested in FuelCell Energy's 100 kW System for ~2,000 hours.**
- **50% lower cost than state-of-the art after production of 100 units**
- **Potential to further lower cost by additional 20% with the use of Additive manufacturing**
- **Demonstration of collaboration between two standalone projects**



SOFC Accomplishments

Aris Energy Solutions

- **3-year project between Aris Energy, NETL, WVU, and NASA**
- **SOFC Systems Testing at NETL Morgantown, WV Site**
- **NETL is testing dynamic operation of 4 X 1.5 kW BlueGEN SOFC systems distributed by Aris, manufactured by SOLIDPower**
- **5.6 kW of power exported to NETL MGN grid beginning 12/2021**
- **Providing technical guidance to WVU/NASA for larger installation in Fairmont, WV**

Systems installed at NETL Morgantown

FY 2021 FOA (DE-FOA-002400)

FOSSIL ENERGY BASED PRODUCTION, STORAGE, TRANSPORT AND UTILIZATION OF HYDROGEN APPROACHING NET-ZERO OR NET-NEGATIVE CARBON EMISSIONS

Develop technologies to reinvigorate the use of the United States' vast fossil-fuel resources and power infrastructure for net-zero carbon energy and commodity production through the production, transport, storage, and utilization of fossil-based hydrogen with zero or negative carbon emissions.

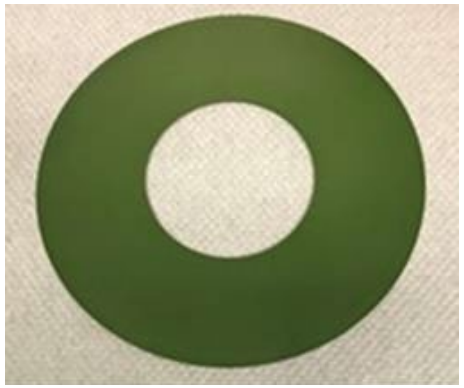
- Issue date: 1/15/2021
- Close date: 3/8/2021
- AOI 5: Solid Oxide Electrolysis Cell (SOEC) Technology Development for Hydrogen Production
- Total DOE Funds: $8M
- Number of awards: 8

FOA-002400 Awards

Awardee	Title
Georgia Institute of Technology	Durable and High-Performance SOECs Based on Proton Conductors for Hydrogen Production
Massachusetts Institute of Technology	Improving Durability and Performance of Solid Oxide Electrolyzers by Controlling Surface Composition on Oxygen Electrodes
OxEon Energy LLC	Development of Stable Solid Oxide Electrolysis Cell for Low-Cost Hydrogen Production
The Regents of the Univ. of Calif., U.C. San Diego.	Development of Novel 3D Cell Structure and Manufacturing Processes for Highly Efficient, Durable and Redox Resistant Solid Oxide Electrolysis Cells
University of Louisiana at Lafayette	Development of High-Performance Metal-Supported SOECs and Innovative Diagnostic Methodologies
University of South Carolina	Developing Stable Critical Materials and Microstructure for High-Flux and Efficient H_2 production through Reversible Solid Oxide Cells
West Virginia University Research Corporation	Designing Internal Surfaces of Porous Electrodes in Solid Oxide Electrolysis Cells for Highly Efficient and Durable Hydrogen Production
Worcester Polytechnic Institute	Heterostructured Cr Resistant Oxygen Electrode for SOECs

SOEC Accomplishments

FuelCell Energy



Cell with active area of 81 cm^2

Compact Stack Architecture (CSA)

Stack size for system demonstration

0.87 KW SOFC
1.6 KW SOEC

2.8 KW SOFC
5.4 KW SOEC

6.7 KW SOFC
12.7 KW SOEC

SOFC Program: Takeaways

- Conducting basic R&D to address critical needs and mature technology – SOFC and SOEC
- Acquiring fabricating and operational experience on integrated, prototype SOFC field tests
- Focusing on hybrid systems to produce hydrogen in SOEC mode and electricity in SOFC mode
- Prior and on-going SOFC R&D supported by FECM will provide the technology basis for SOEC development going forward

Questions?

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https://netl.doe.gov/coal/research/energy-systems/fuel-cells

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REFERENCE SHELF:

- SOFC Program Project Portfolio
- Workshop Proceedings
- Systems Analysis

SOFC
SOLID OXIDE FUEL CELL