Fuel Cells Program Overview

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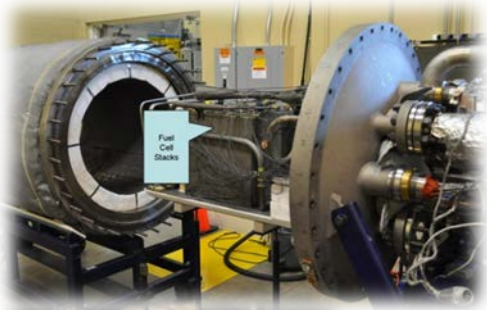
SECA Program Structure

Industry Input

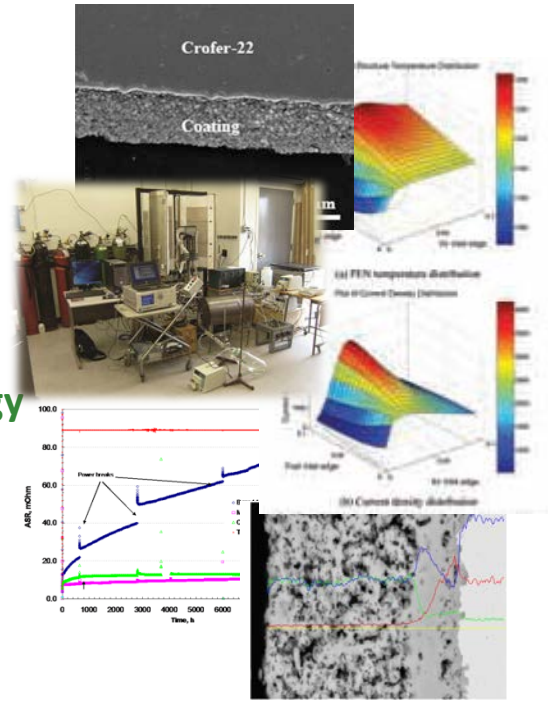
Program Management



Project Management

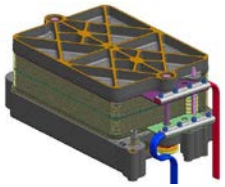
Needs

Research Topics



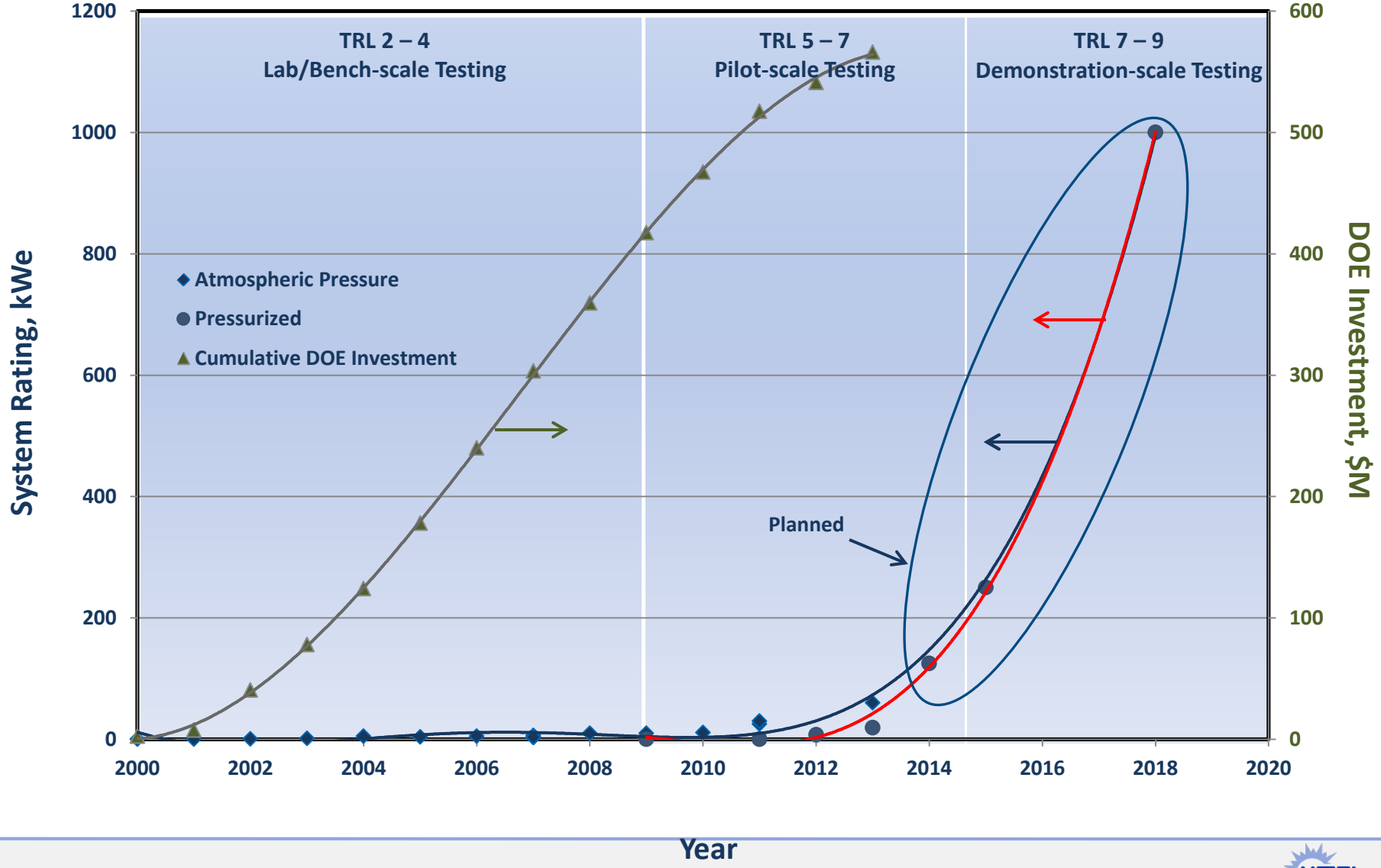
Industry Teams

Core Technology Program

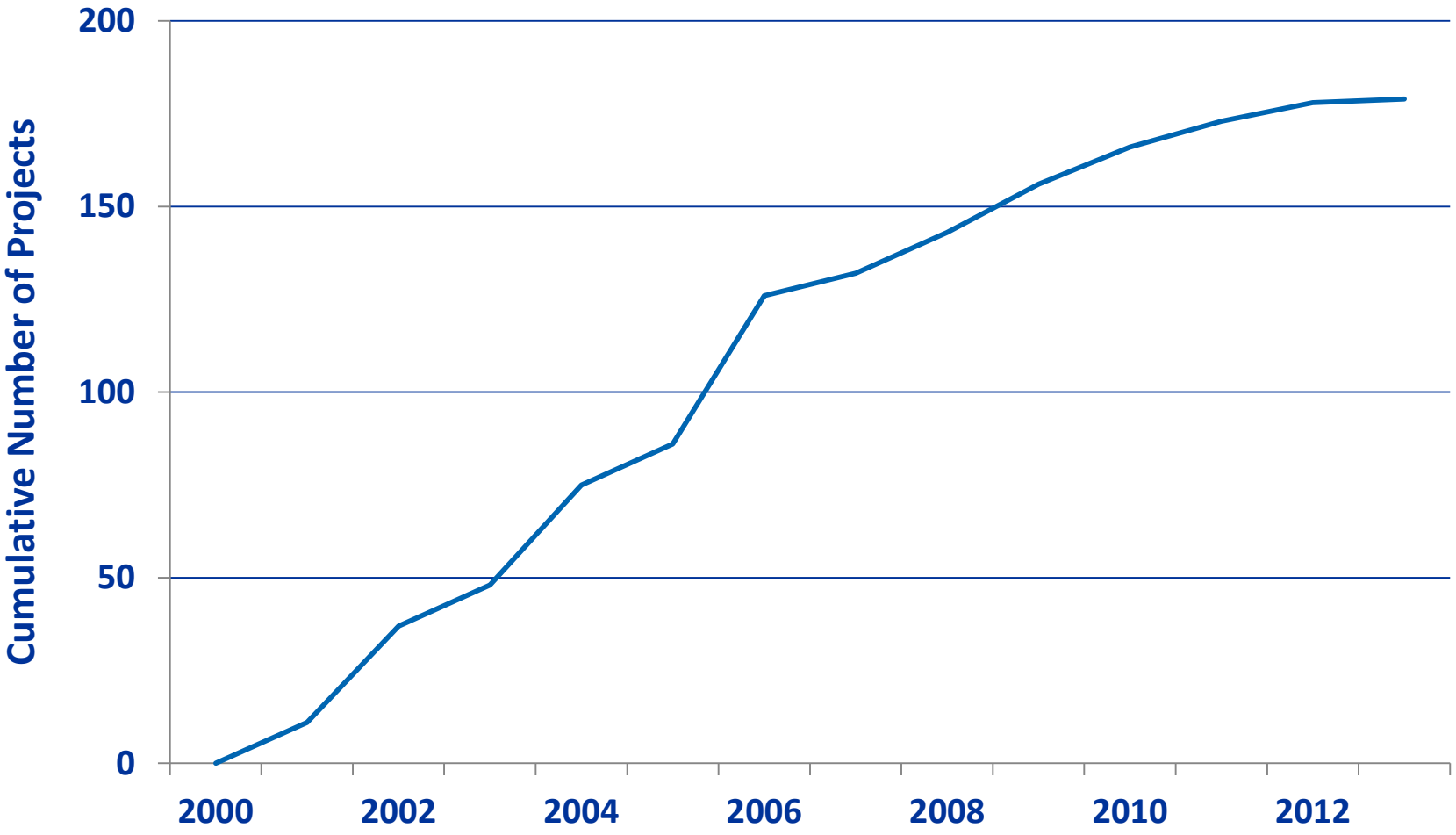


Technology Transfer

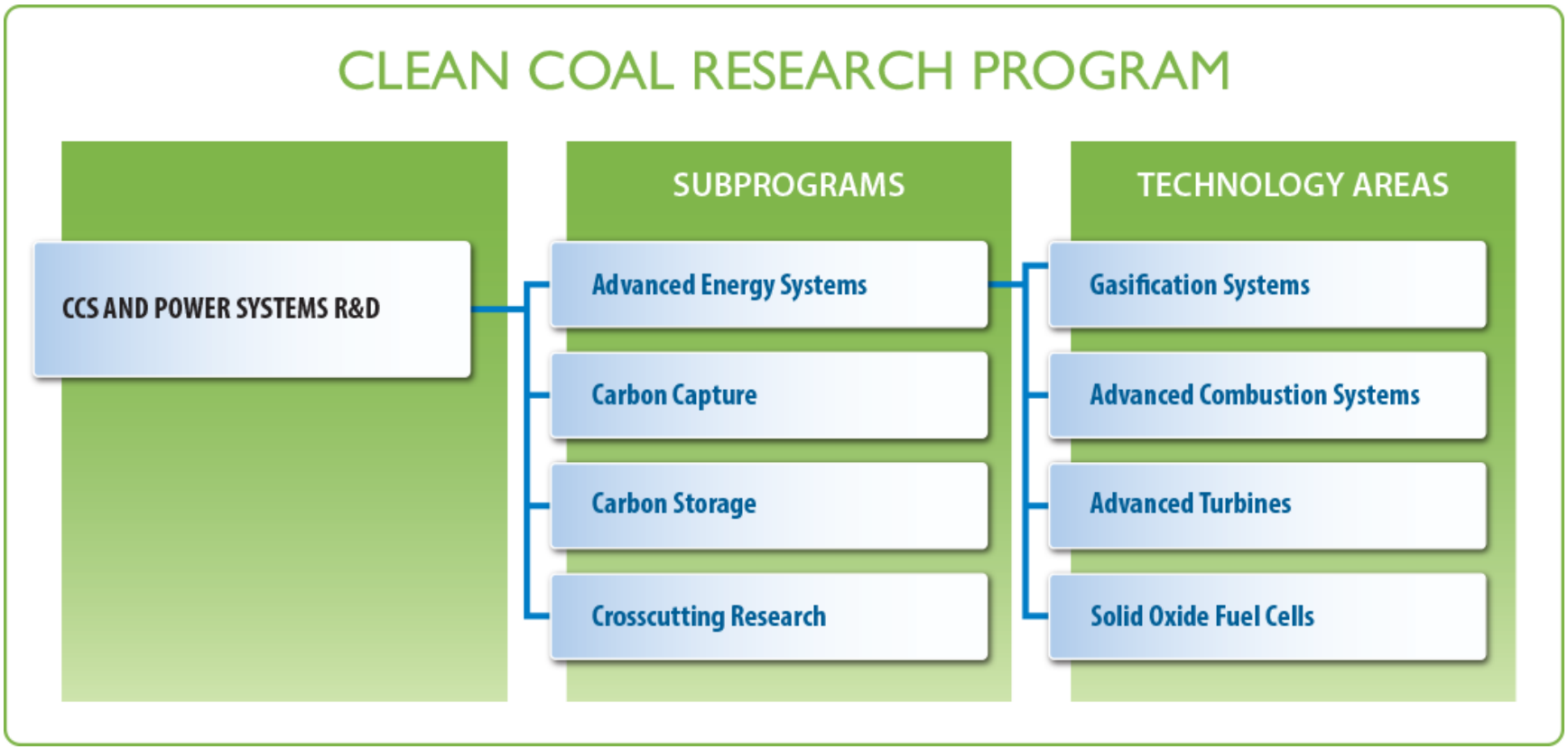
SECA Technology Development Timeline



The SECA Program – A Decade of Growth



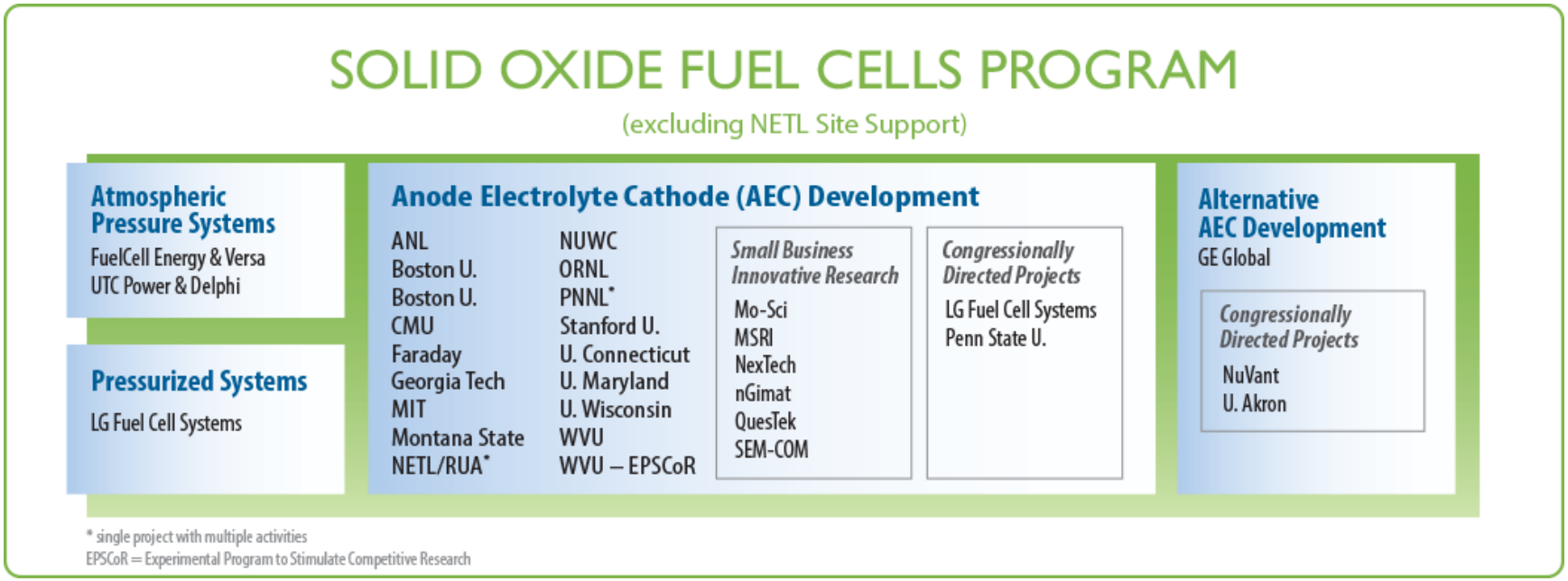
Clean Coal Research Program



Budget

	FY 12 ($M)	FY 13 ($M)
Advanced Energy systems		
Gasification Systems	39.0	37.1
Advanced Combustion Systems	16.0	15.2
Hydrogen Turbines	15.0	14.3
Fuels	5.0	4.8
Solid Oxide Fuel Cells	25.0	23.8
Total	**100.0**	**95.2**

SECA Project Portfolio

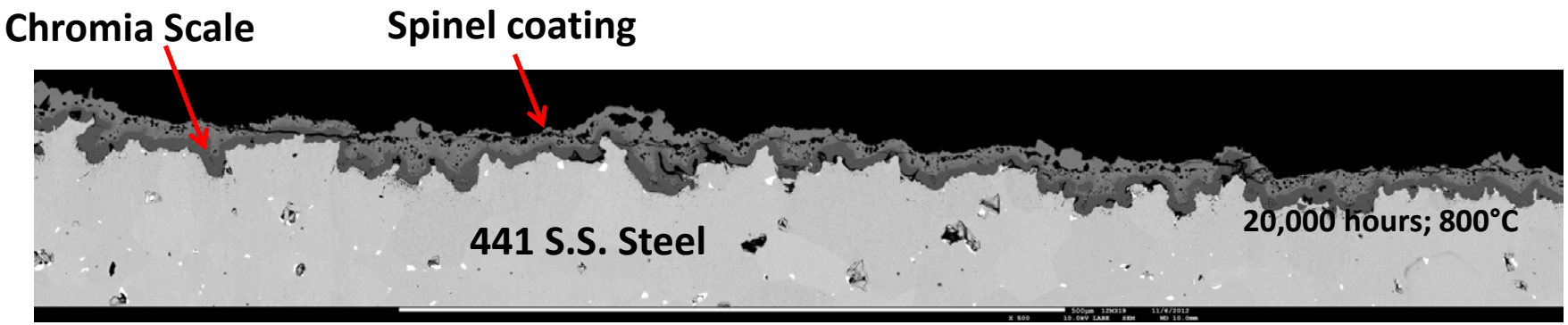


Accomplishments

Pacific Northwest National Laboratory (PNNL)

Cost-Effective Interconnect Materials for Planar SOFC

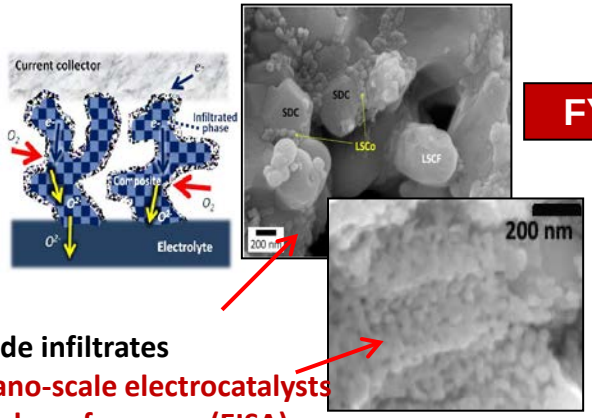
- **Technical Approach:** Conventional ferritic stainless steel (AISI 441) with protective MnCo spinel coating for active areas and reactive air aluminization for sealing surfaces
  - Protective coatings mitigate Cr volatility, scale growth, and increased electrical resistance over time
- **Remaining Challenge:** Scale spallation during long-term operation
  - Unmodified surfaces can exhibit scale spallation after ~5,000 hours at 800ºC
- **Proposed Solution:** Modification of steel surface via inexpensive surface treatment (e.g., surface blasting or grinding)



Modified surfaces exhibit no spallation after 26,000 hours 800ºC

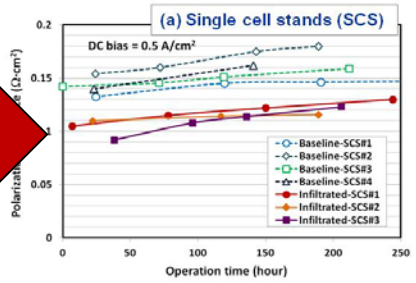
NETL – Office of Research and Development

Infiltration concept



Cathode infiltrates
- Nano-scale electrocatalysts
- High-surface area (EISA)

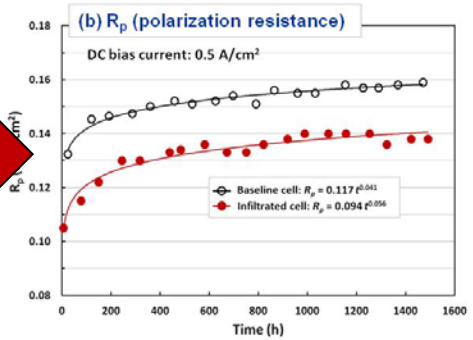
FY10



(a) Average Rp after 24 h operation (SCS)
Baseline cells: 0.14 ± 0.009 Ωcm²
Infiltrated cells: 0.10 ± 0.012 Ωcm²

FY11

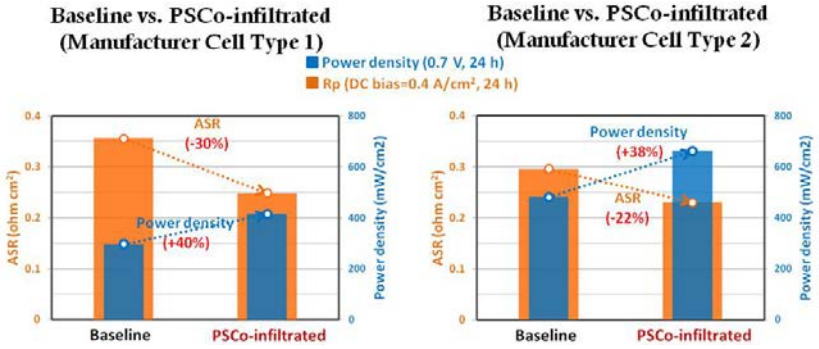
Long-term stability verification



Short-term performance validation

FY12

Industry Engagement



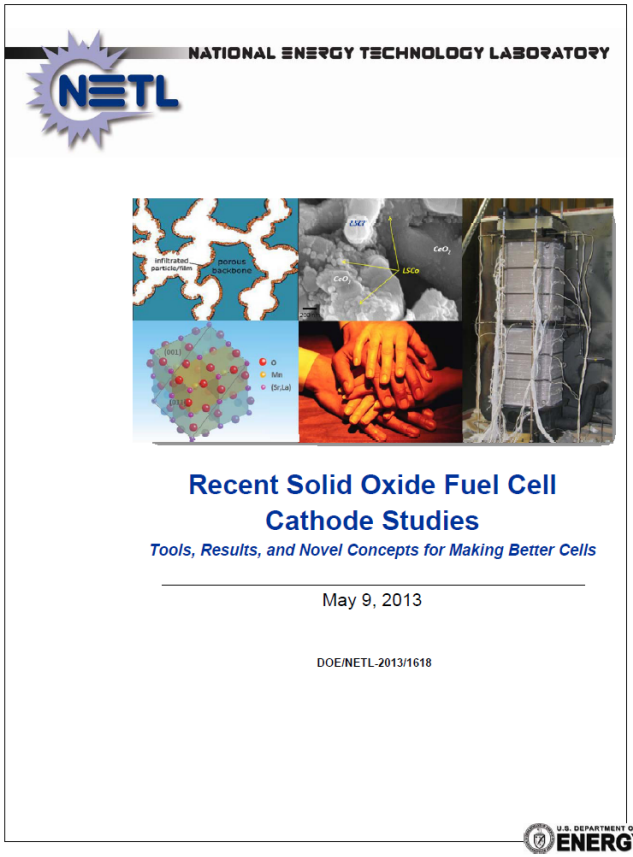
FY13

Short stack validation
- **Industry Team 1**
  - **1000 hour, 5-cell test completed**
- **Industry Team 2**
  - **Multiple cell tests completed**
  - **Total cell time exceeds 500 hours**
- **Scale-up and manufacturing process development pursued through FY14**

Cathode Development

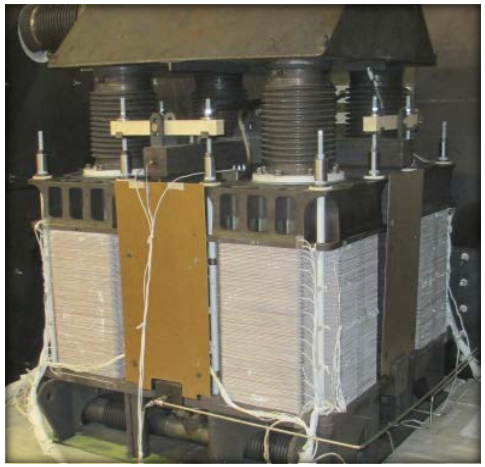
- 7 new projects underway
- Coordinating with Industry Team priorities
- Focusing on intrinsic stability and robustness to CO_2 and H_2O
- <u>Key Accomplishments</u>
  - Infiltrated short stacks for evaluation
  - Quantifying effects of H_2O

Compilation Complete & on SECA Website



http://www.netl.doe.gov/technologies/coalpower/fuelcells/seca/refshelf.html

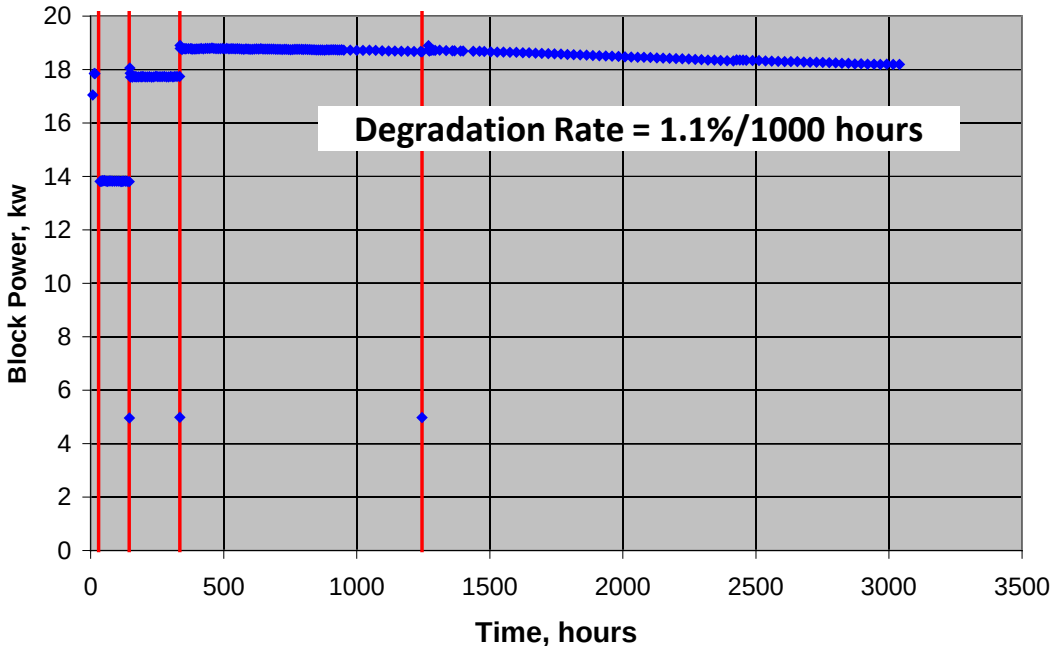
FuelCell Energy – Stack Test

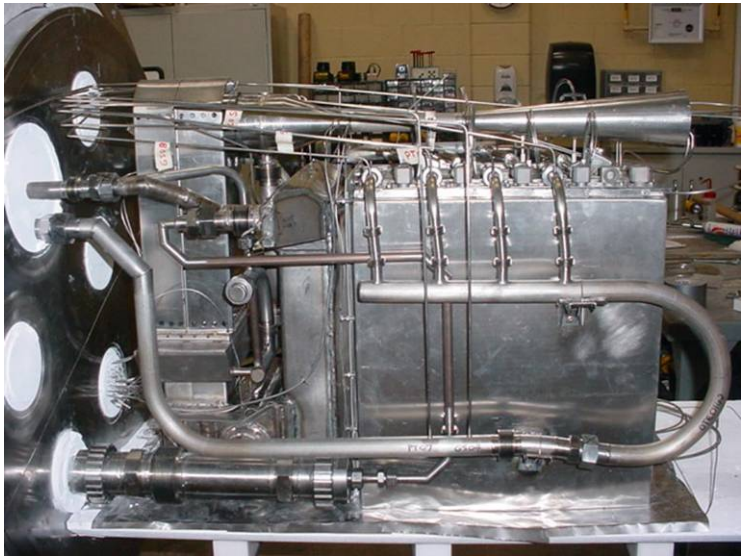


- 60 kW SOFC module installed in grid-connected Power Plant Facility
- Max Power: 60.6 kW
- >1500 hours of hot operation

LG Fuel Cell Systems – Stack Test

- **18.8 kW output at design point current**
- **3040 hours operation in thermally self-sustaining test rig**
- **Power degradation 1.1%/1000 hours**
  - Degradation mechanisms identified, improvements to be implemented in next block-scale test





Delphi

- **Completed scale up of cells from 105 cm^2 (active area) cells to 403 cm^2 for Gen 4 stacks**
- **Added additional Gen 4 stack fabrication and testing capabilities**
- **Fabricated and tested 24 Gen 4 stacks and 55 Gen 3 stacks in past year**
- **Demonstrated 7,000+ hours continuous durability on Gen 3.2 stack; demonstrated 5,000+ hours on Gen 4 stack.**

FY13 Solid Oxide Fuel Cell Program

An Added Dimension

FOSSIL ENERGY RESEARCH AND DEVELOPMENT

(INCLUDING RESCISSION)

Appropriations, 2012	[1] $534,000,000
Budget estimate, 2013	$420,575,000
Committee recommendation	$460,575,000

[1] Does not include rescission of $187,000,000 under Public Law 112–331.

The Committee recommends $460,575,000 for Fossil Energy Research and Development. This is $40,000,000 more than the budget request.

CCS and Power Systems.—The Committee recommends $301,622,000 for CCS and Power Systems. Within the available funding, Advanced Energy Systems is funded at $80,946,000. Of this funding, $25,000,000 is to continue the Department's research, development, and demonstration of solid oxide fuel cell systems, which have the potential to increase the efficiency of clean coal power generation systems, to create new opportunities for the efficient use of natural gas, and to contribute significantly to the development of alternative-fuel vehicles. Further, within Gasification Systems, a subprogram of Advanced Energy Systems, the recommendation includes $8,000,000, the same as provided in fiscal year 2012, to continue activities improving advanced air separation technologies.

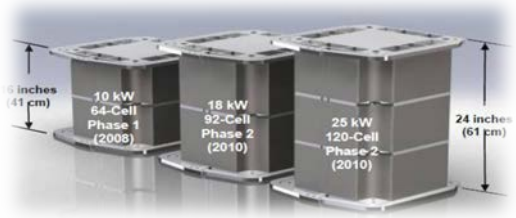
The United States is experiencing a significant increase in natural gas production and use in the United States. The Committee is aware that some of the research and development work being conducted within the CCS and Power Systems programs for coal are also potentially applicable to natural gas. The solid oxide fuel cell systems are an example of research and development that is applicable to both coal and natural gas power generation. The Department is directed to use funds from this program for both coal and natural gas research and development as it determines to be merited.

SOFC Program Timeline

2010 2015 2020 2025 2030

Demonstrations

- Stack Building Block >20 kW
- System Module >30 kW
- POC >125 kWe
- 250 kW to MWe-Class
- IGFC Commercial Scale
- Non-Fuel Cell Program Funded NG DG Demos
- Non-Fuel Cell Program Funded NG Utility Pilot and Demos



R &D

Technologies critical to commercialization

Research Focus

- Improved electrochemical performance
- Increased power density
- Reduced long-term degradation rates
- Improved mechanical integrity
- Reduced material cost
- Cell/stack integration and scale-up

SECA Program Participants

For More Information on the SOFC Program

Office of Fossil Energy: www.energy.gov/fe/office-fossil-energy

NETL Website: www.netl.doe.gov/

SOFC Program: www.netl.doe.gov/technologies/coalpower/fuelcells/index.html

Reference Shelf:

- SOFC Program FY13 Project Portfolio
- SOFC Technology Program Plan
- Technology Readiness Assessment
- Past SECA Workshop Proceedings
- Systems Analysis
- Fuel Cell Handbook

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