



13th Annual SECA Workshop SECA Program Overview - 2012

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Fuel Cells/Fuels Technology Manager
National Energy Technology Laboratory

July 24, 2012



Solid Oxide Fuel Cell Team



- *Eric Bell, Business Management Specialist*
- *Patcharin Burke, Project Manager*
- *Neha Gupta, Intern*
- *Maria Reidpath, Project Manager*
- *Heather Quedenfeld, Division Director*
- *Travis Shultz, Project Manager*
- *Joseph Stoffa, Project Manager*
- *Briggs White, Project Manager*
- *Dan Driscoll, Technology Manager*

SECA Program Mission



- Enable the generation of efficient, cost-effective electricity from domestic coal ***and natural gas*** with near-zero atmospheric emissions of CO₂ and air pollutants and minimal use of water in central power generation applications.
- Increase reliability, robustness, and durability of cell and stack technology.
- Provide the technology base to permit grid-independent distributed generation applications.

60%
Efficiency
(Coal HHV)

≥ 99% CO₂
Capture

Environmental:
<0.5ppm NO_x,
low H₂O use

Low Cost,
similar footprint
to IGCC

Modular
Technology

Fuel-Flexible:
Syngas, NG,
H₂, Diesel,
etc.

Solid State Energy Conversion Alliance (SECA) Program History



- 2000 – SECA formed, emphasis on Core R&D, Cost Reduction
5 kWe mass-produced modules, natural gas fuel
- 2001 - First Industry Teams Selected
- 2005 - First Cost Goal Achieved
Successful Prototype Tests
Coal-based Systems Industry Teams Selected
- 2007 - Industry Teams Achieve Phase I Objectives
 - 3-7 kWe, 35-41% efficiency
 - <2%/1000 hr degradation rate
 - >1500 hr operation @ >95% availability
 - <\$775/kWe
 - Conceptual design of a mature-technology central station power plant
- 2011 – Phase II Objectives Achieved
 - ~25 kWe
 - <1%/1000 hr degradation rate
 - >1500 hr operation
 - <\$700/kWe

SECA Program Structure



Industry Input

Program Management



Project Management

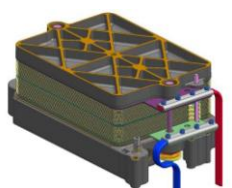


Needs

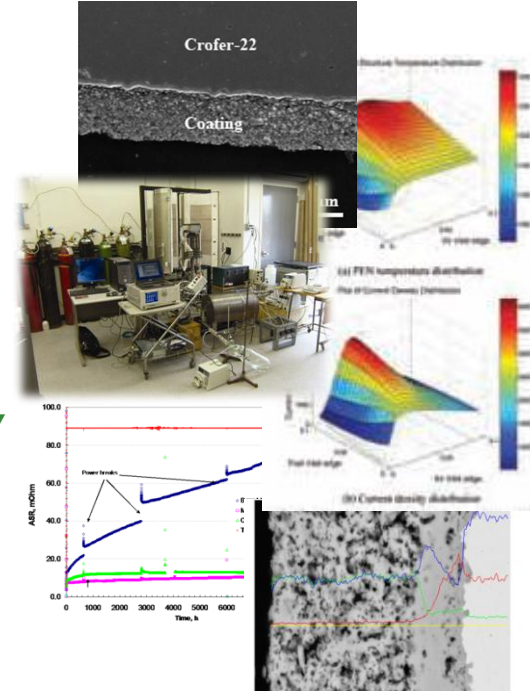
Research Topics

Industry Teams

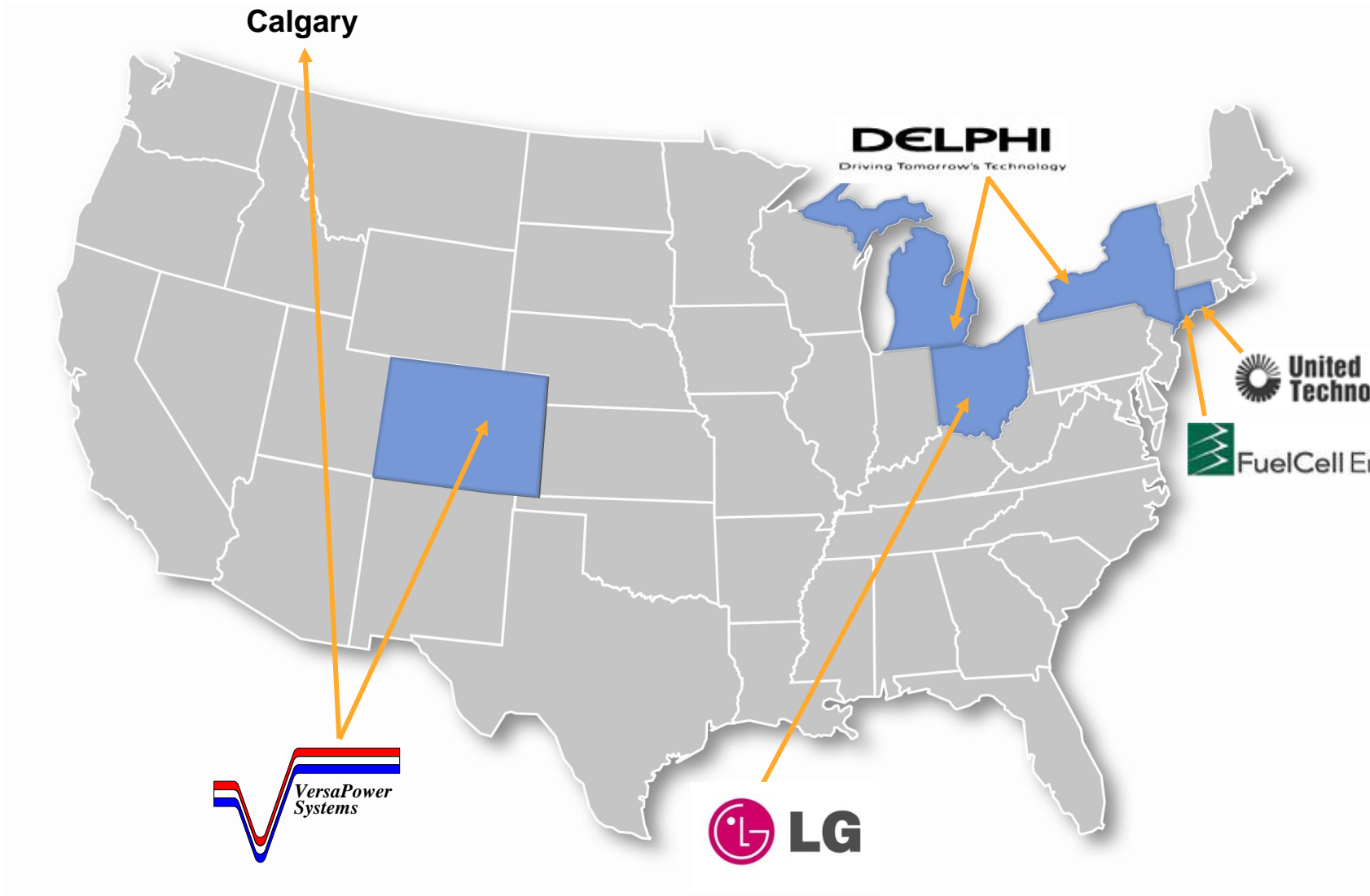
Core Technology Program



Technology Transfer



SECA Industry Teams



SECA Core Technology



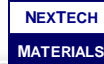
Pacific Northwest National Laboratory
U.S. Department of Energy

MONTANA STATE UNIVERSITY



Alfred University

Carnegie Mellon



Eltron Research & Development



MSRI



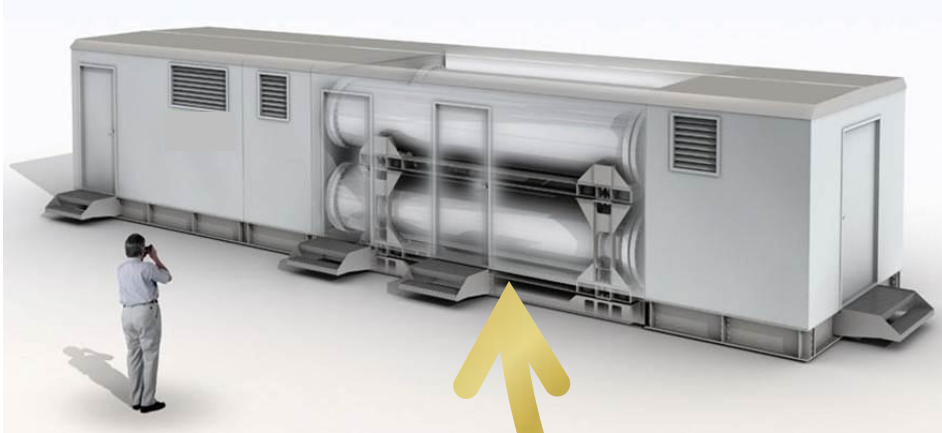
UNLV
UNIVERSITY OF NEVADA LAS VEGAS

OAK RIDGE NATIONAL LABORATORY



SECA Industry Team Accomplishments

LG Fuel Cell Systems



*1 MWe Natural Gas Distributed Generation System
(artist's rendering)*

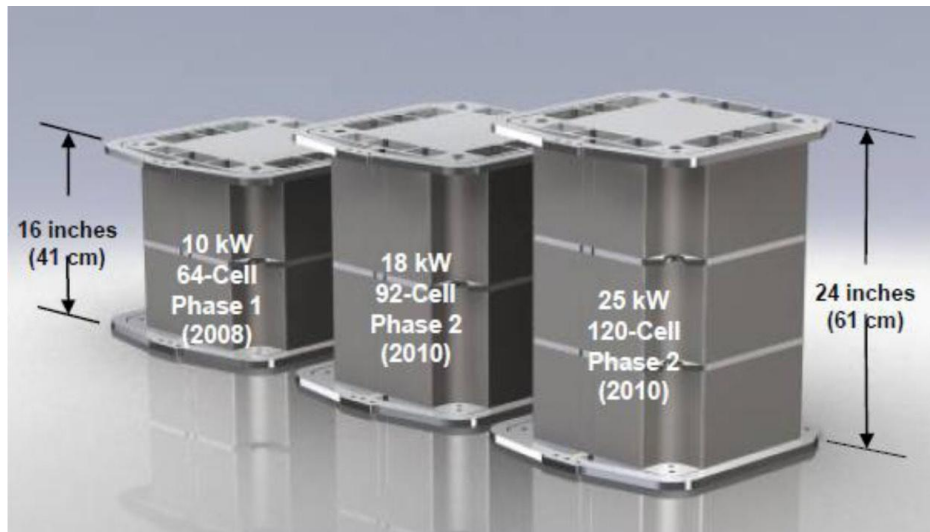
*LG Fuel Cell Systems
Fuel Cell Stack*



© 2012 Rolls-Royce Fuel Cell Systems (US) Inc.

SECA Industry Team Accomplishments

Fuel Cell Energy/Versa Power



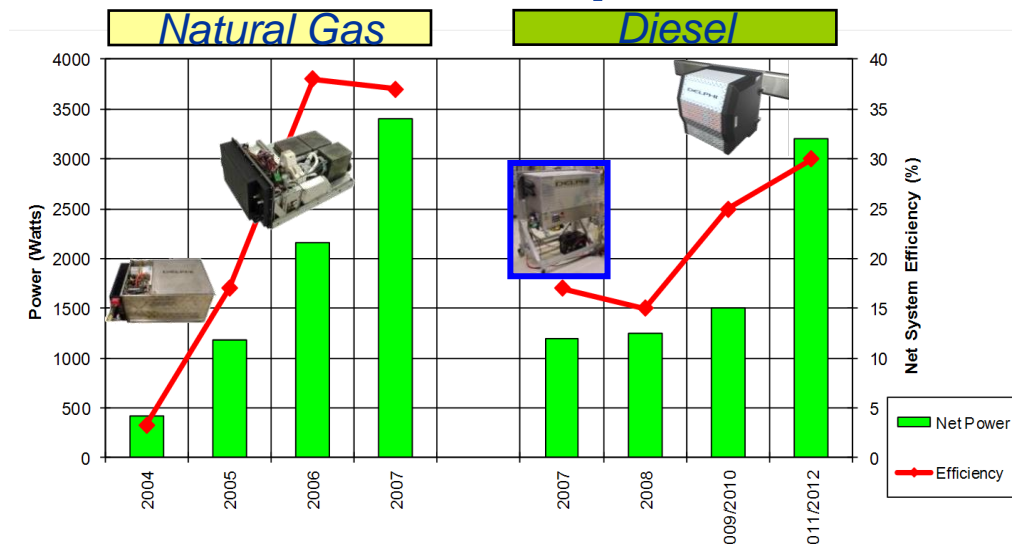
Evolution of the FCE/VPS SOFC Stack (2008 – 2010)

FCE/VPS SOFC 30 kW Stack Tower (192 cells) (2012)



SECA Industry Team Accomplishments

UTC/Delphi



SECA Industry Team Accomplishments



Fuel Cell Energy & Versa Power Systems

- Cell degradation rate reduced to $<0.3\%/1,000$ hrs
- End-of-Phase II stack test achieved >25 kWe, 1,500 hrs, met all metrics
- Developed IGFC (~ 670 MW) concept utilizing catalytic gasifier, $>99\%$ carbon capture, electrical efficiency $>58\%$ (HHV, coal)

UTC & Delphi

- Scaled-up cell active area by 4x (Gen 4 vs Gen 3) - $>400\text{cm}^2$
- Gen 3 stack test > 1 kW, completed 9,700 hrs, 200 thermal cycles, degradation rate $\sim 1.1\%/500$ hrs
- Gen 4 stack test underway, $>3,000$ hrs, >200 thermal cycles

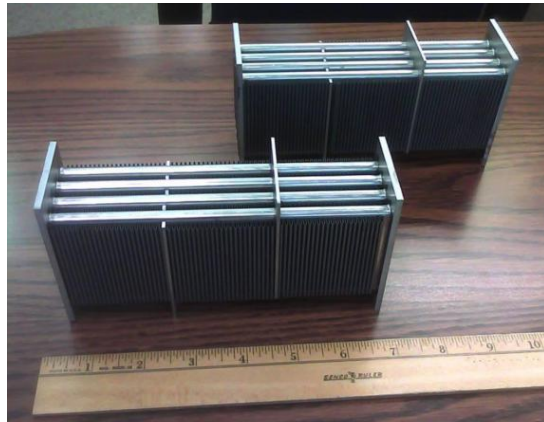
LG Fuel Cell Systems

- Cell improvements being screened for reduced degradation rates
- Pressurized (6.4 bara) subscale tests exceeded 16,000 hrs, degradation rate $<1\%/1,000$ hrs
- 7.6 kW metric test under full system conditions degrading @ $<1\%/1,000$ hrs

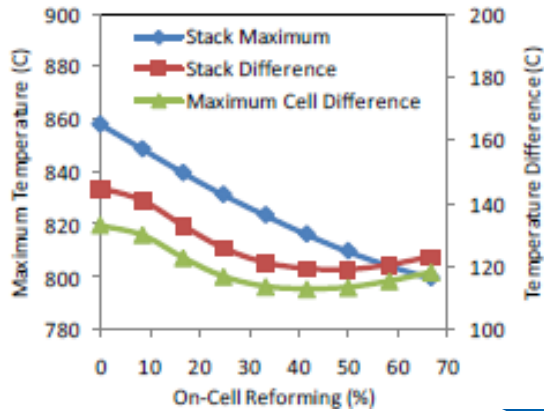
SECA Core Team



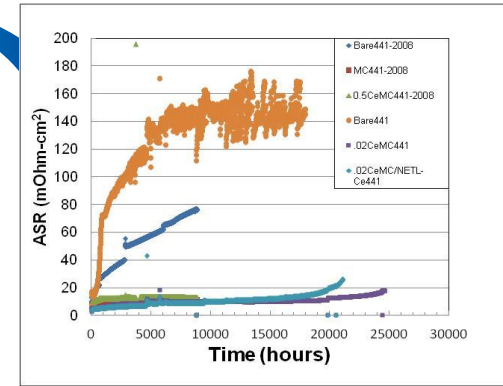
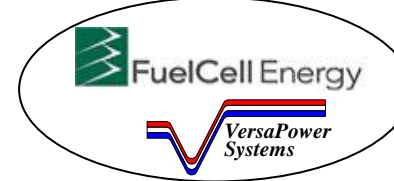
The Core Technology Program, made up of universities, national laboratories, small businesses, and other R&D organizations, addresses applied technological issues common to all Industry Teams.



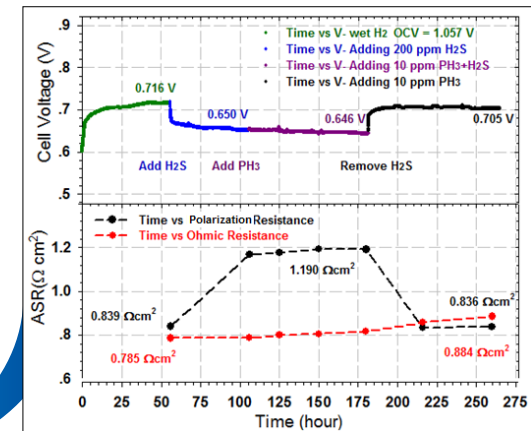
BOP – Heat Exchangers



Cell/Stack Modeling



Interconnects



Coal Contaminants

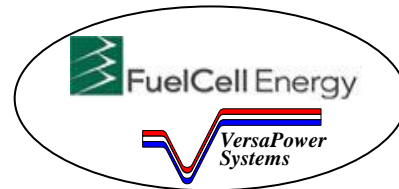
SECA Core Team - Intellectual Property



Cornerstone of the Alliance

Industry Teams

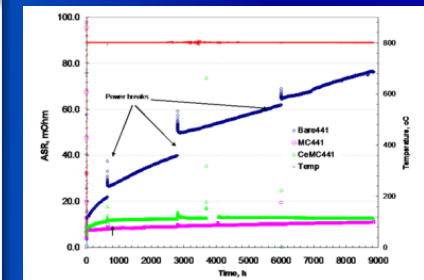
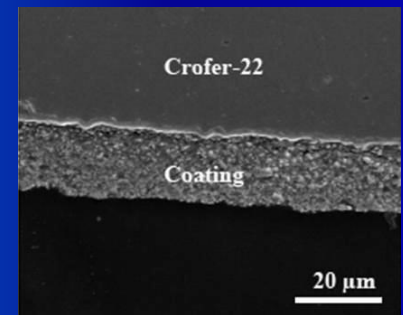
Develop Proprietary Technologies



Non-Exclusive Licenses

- Industry teams engaged to identify research topics
- Forward looking systems analysis
- Promotes collaboration
- Limits research redundancy

SECA Core Teams



SECA Core Team Accomplishments



Cathodes

- Demonstrated statistically significant performance improvement for infiltrated cathodes - without major material set changes.
- Verified stability of electrochemical performance in 1500 hour test.

Materials

- Spinel-coated 441SS appears promising as cost-effective interconnect material exhibiting stable performance.

Seals

- Compliant glass seals are being developed to increase the reliability and robustness of SOFC sealing systems. Candidate glasses have demonstrated excellent thermal cycle stability, thermal stability, and chemical compatibility with SOFC materials.

Modeling

- Modeling of interconnect scale-spallation with varying surface treatments agrees with experimental data.
- 2D model verified by real stack test data.

SECA Program - Project Portfolio

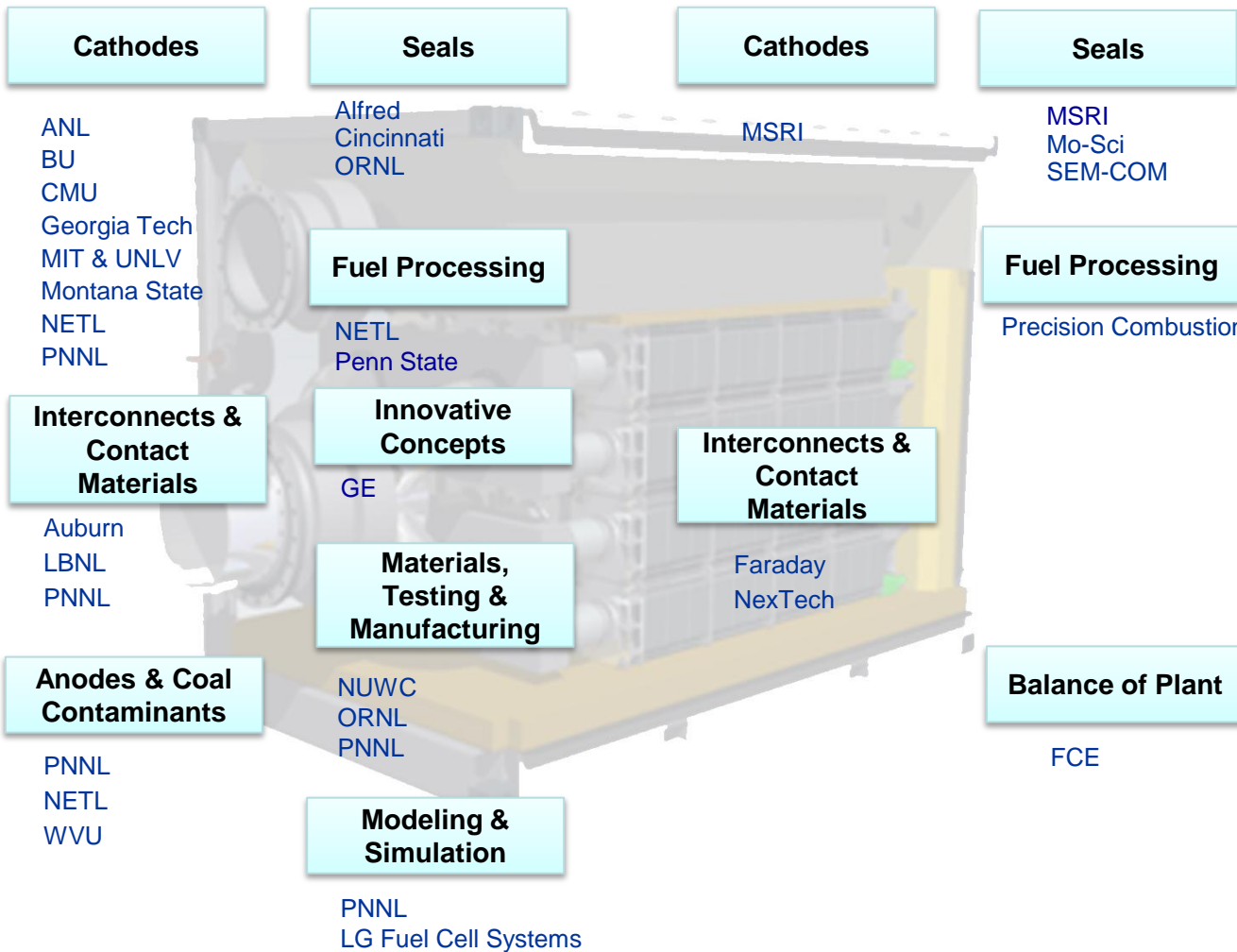


Industry Teams

FCE & VPS
UTC Power & Delphi
LG Fuel Cell Systems

Core Technology

SBIRs



SECA Core Technology

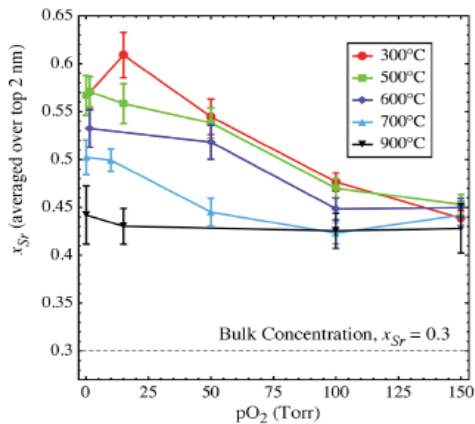
Cathode R&D – World-class Performance



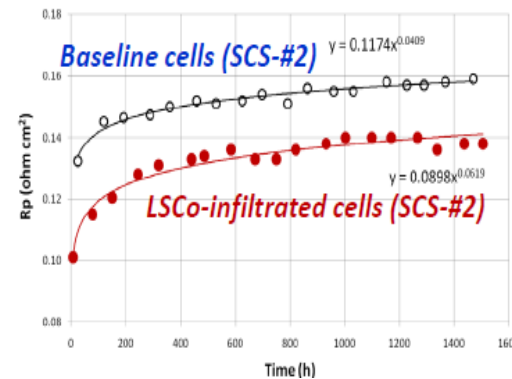
The right people, working on the right issues, producing results ...



Pushing the application of surface science techniques from laboratory conditions to real-world operating conditions



Fundamental data

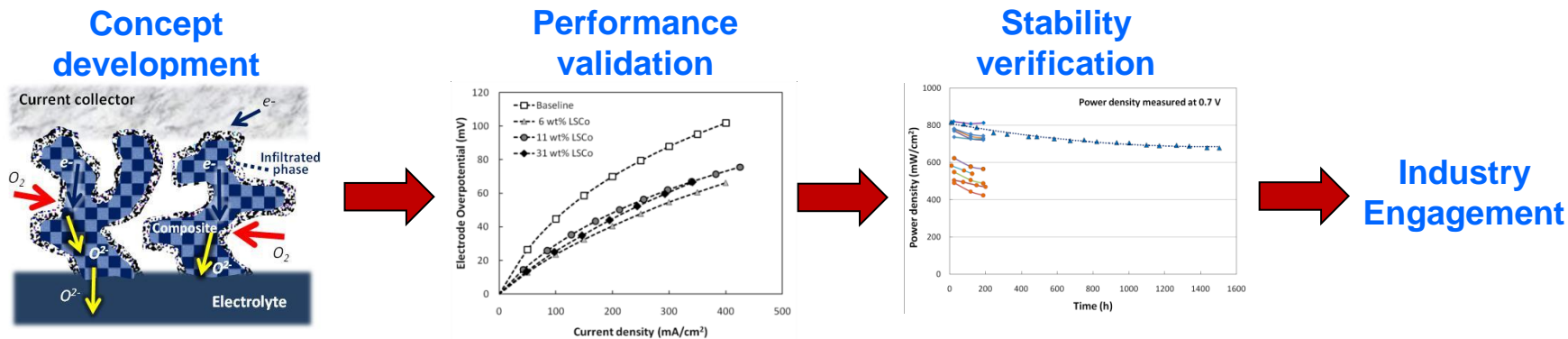


Cell data

NETL – Office of Research & Development (ORD)



- Supports industrial development, develops innovative technology, and evaluates advanced concepts



• NETL/Regional University Alliance

- Carnegie Mellon
- Pennsylvania State University
- University of Pittsburgh
- Virginia Tech
- West Virginia University
- URS
- NETL



- Added direction: To develop a collaboration between NETL, RUA, and Core Team to conduct directed R&D and validate and verify results

FY12 Funding Opportunity Announcement

(DE-FOA-0000677)

- Title: Solid State Energy Conversion Alliance Core Technology Program
- Objective: To provide scientific and engineering solutions to technical challenges and barriers address specific technical challenges and barriers faced by the SECA Industry Teams, specifically:

Topic Area 1 - Electrochemical Performance Enhancement Activity

- Cell interface constituents on transport and catalytic properties
- Potential cell modifications to increase electrochemical activity
- Processing methodologies

Topic Area 2 – Durability of Cathode Materials

- Investigate effects of real-world conditions (humidity, chrome, contaminants)
- Correlate degradation mechanism with real-world conditions
- Develop test methods and configurations

FY12 Funding Opportunity Announcement

(DE-FOA-0000677)

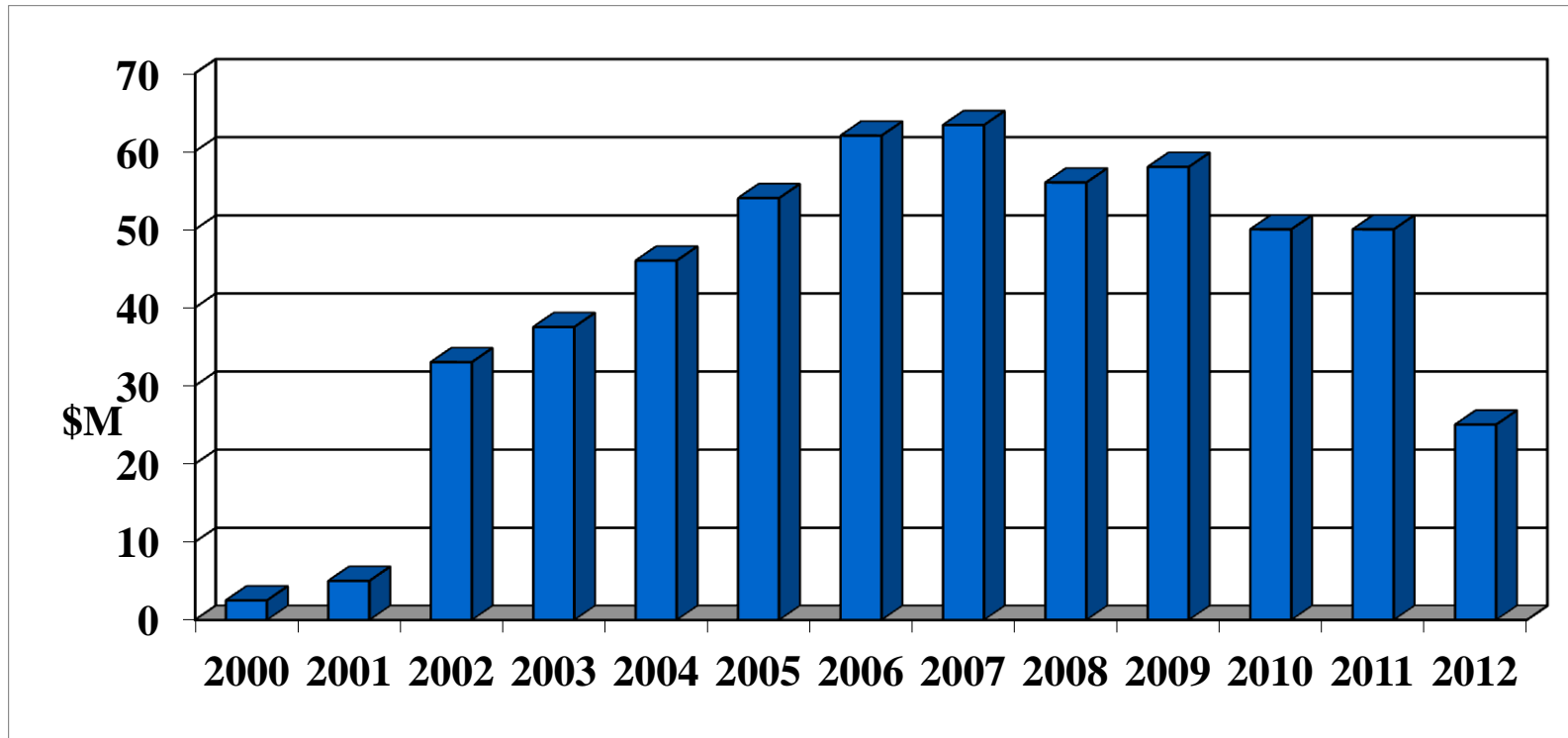
Topic Area 1 - Electrochemical Performance Enhancement Activity

- Leland Stanford Junior University “Surface–Modified Electrodes: Enhancing Performance Guided by *In-Situ* Spectroscopy and Microscopy”
- University of Wisconsin “Enhancement of SOFC Cathode Electrochemical Performance Using Multi-Phase Interfaces”
- Boston University “Unraveling the Role of Transport, Electrocatalysts, and Surface Science in the SOFC Cathode Oxygen Reduction Reaction”
- West Virginia University Research Corporation “Fundamental Understanding of Oxygen Reduction and Reaction Behavior and Developing High Performance and Stable Cathode with Heterostructured Surface”

Topic Area 2 – Durability of Cathode Materials

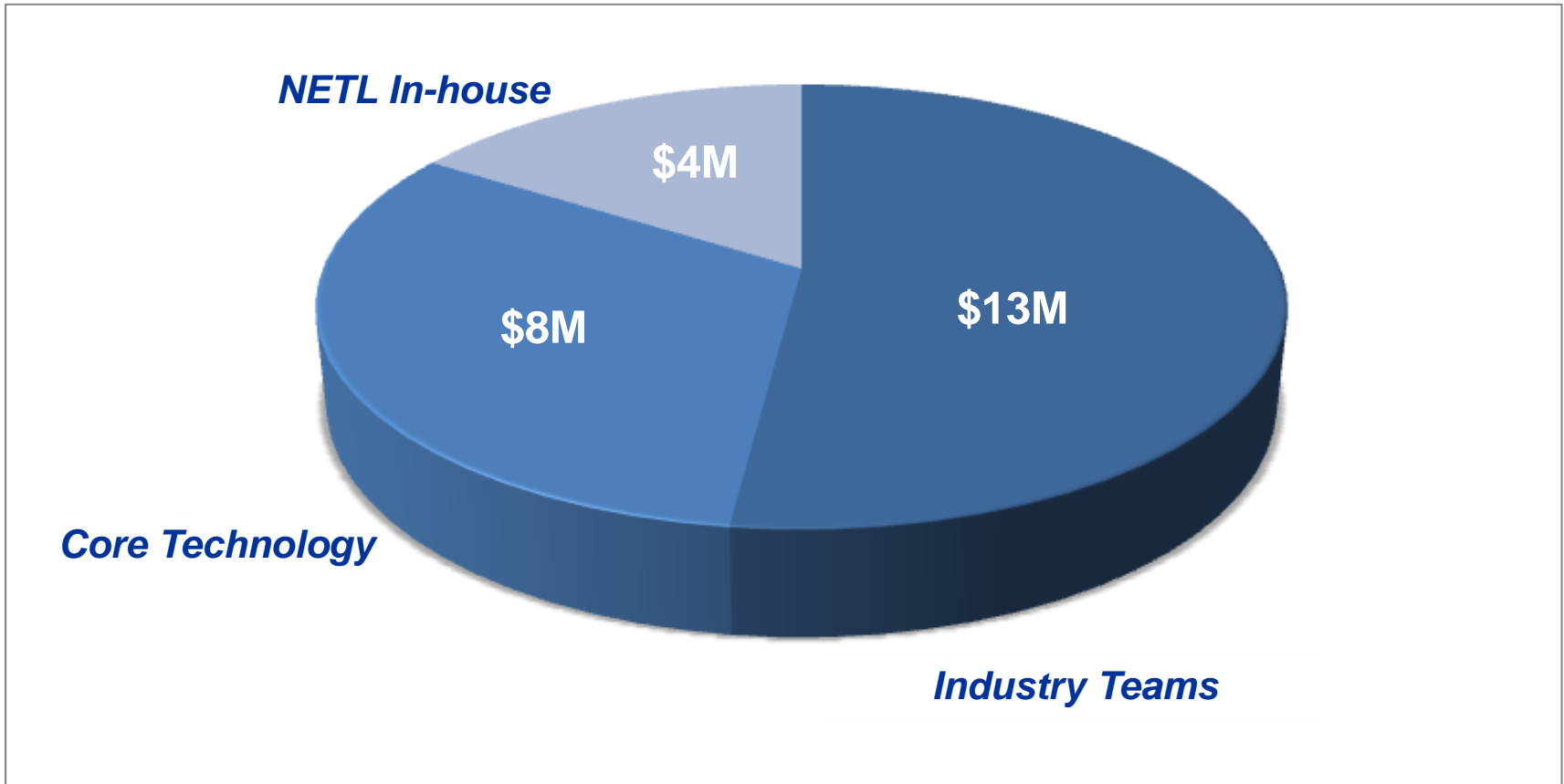
- University of Connecticut “Study of the Durability of Doped Lanthanum Manganite Cathode Materials “Real World” Air Exposures Atmospheres”
- University of Maryland “Mechanistic Enhancement of SOFC Cathode Durability”
- Georgia Tech Research Corporation “Fundamental Investigation and Rational Design of Durable, High-Performance SOFC Cathodes”

Solid Oxide Fuel Cell Program Budget History



Solid Oxide Fuel Cell Program Budget Allocation

FY12 = \$25M



FY13 Solid Oxide Fuel Cell Program A New 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

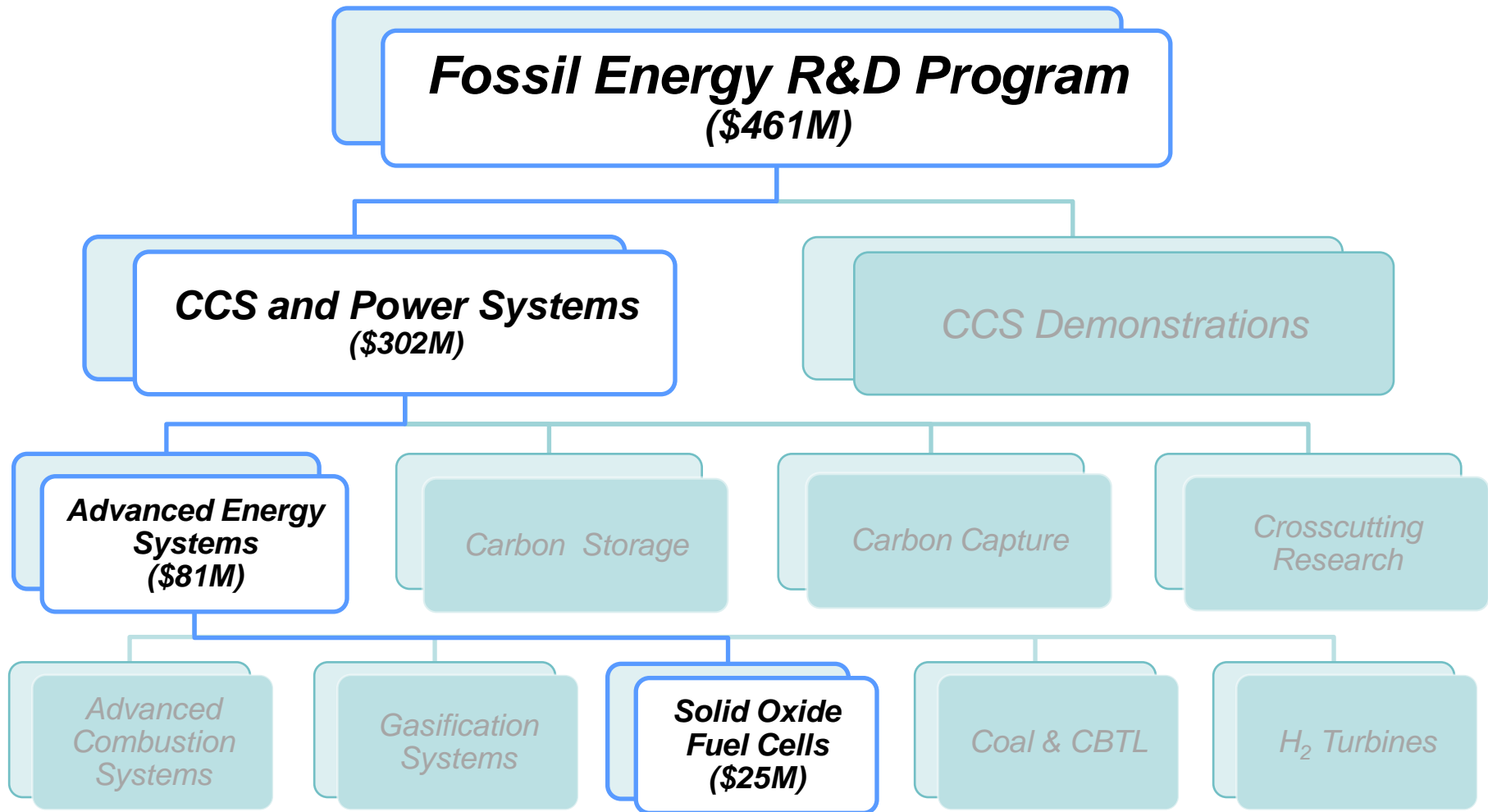
¹ Does not include rescission of \$187,000,000 under Public Law 112–331.

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

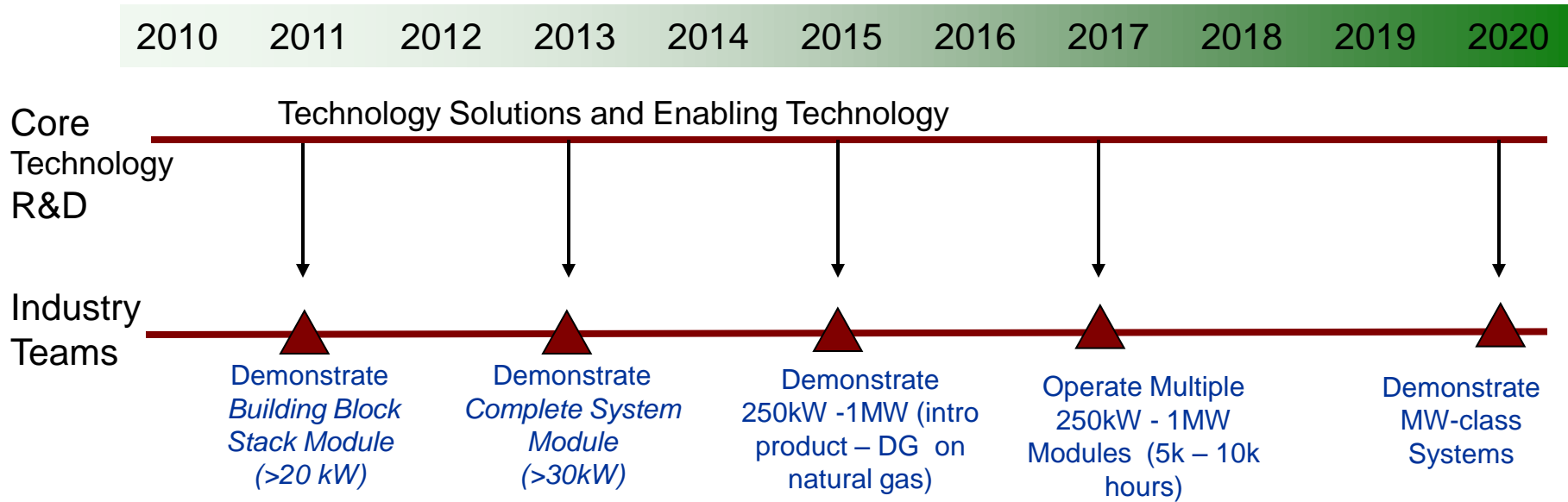
CCS and Power Systems.—The Committee recommends \$301,622,000 for CCS and Power Systems. Within the available funding, Advanced Energy Systems is funded at \$80,946,000. **Of this funding, \$25,000,000 is to continue the Department’s research, development, and demonstration of solid oxide fuel cell systems, 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 and Budget Structure

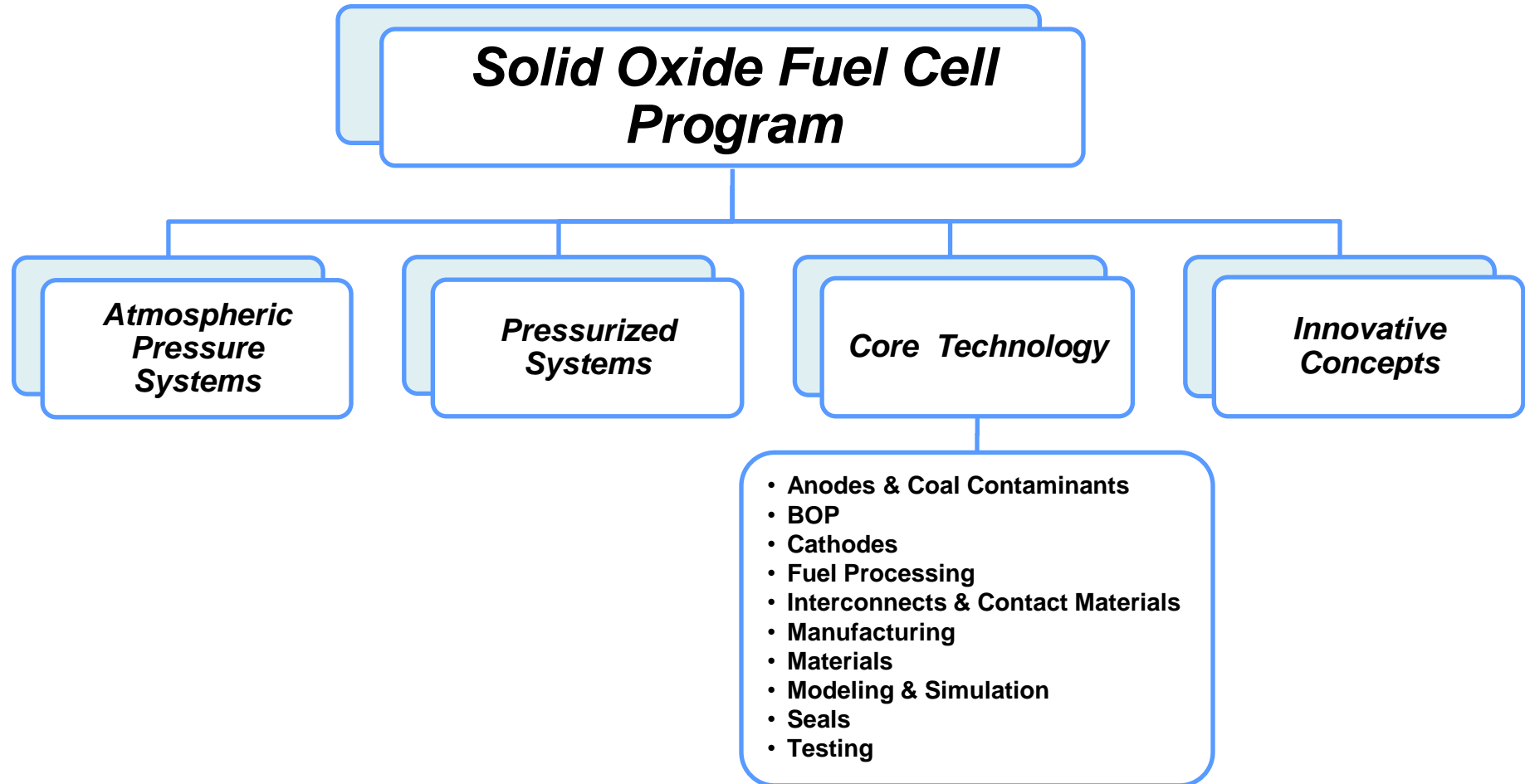


SECA Program Timeline

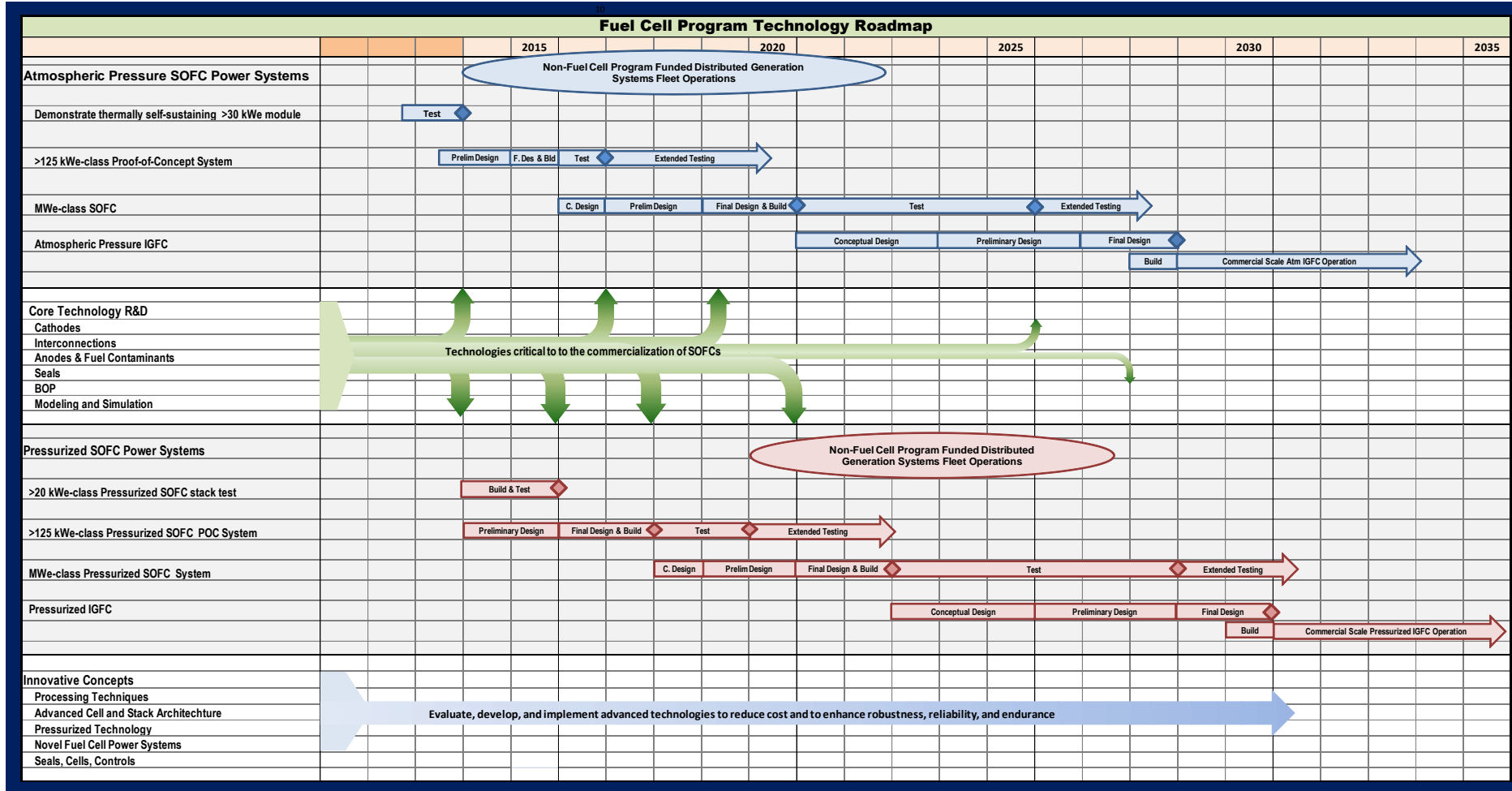


- Progressively larger SOFC stacks and systems
- Maintain cost (\leq \$700/kW power block in 2007 dollars)
- Perform and integrate R&D (Core and Industry Teams) to enhance reliability, robustness, and endurance required for commercial deployment
- Provides the technology base to permit grid-independent distributed generation applications → market entry deployments
- ~1 MW modules form basis for central generation deployments

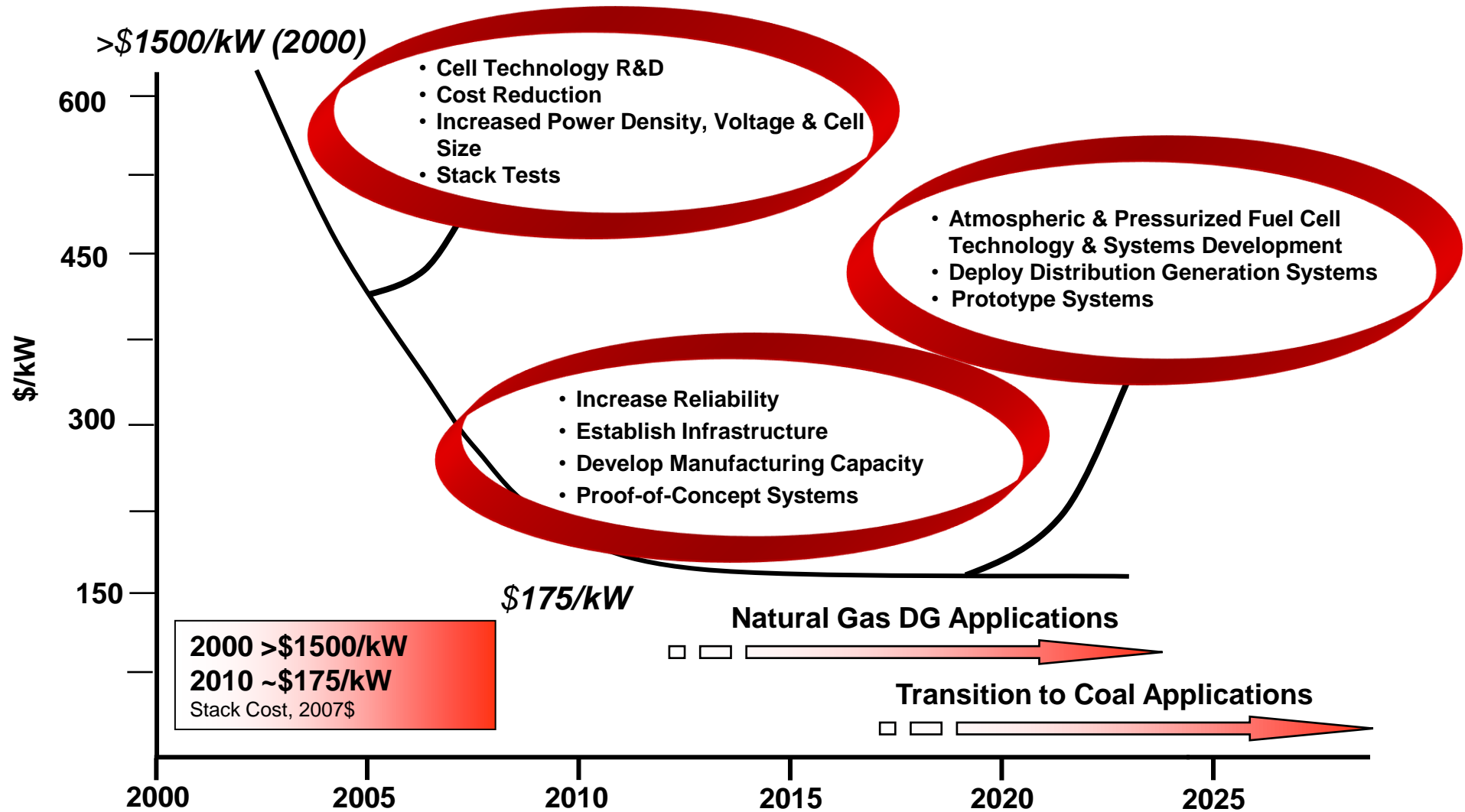
SOFC Program Structure



SECA Program Development Timeline



SECA - Driving Down the Cost of SOFC



For More Information on SECA...



Websites:

www.netl.doe.gov

www.fe.doe.gov

www.grants.gov

CDs available from the website

- Annual SECA Workshop Proceedings
- Fuel Cell Handbook (7th ed.)

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