SECA Core Technology

Fossil Energy Fuel Cell Program

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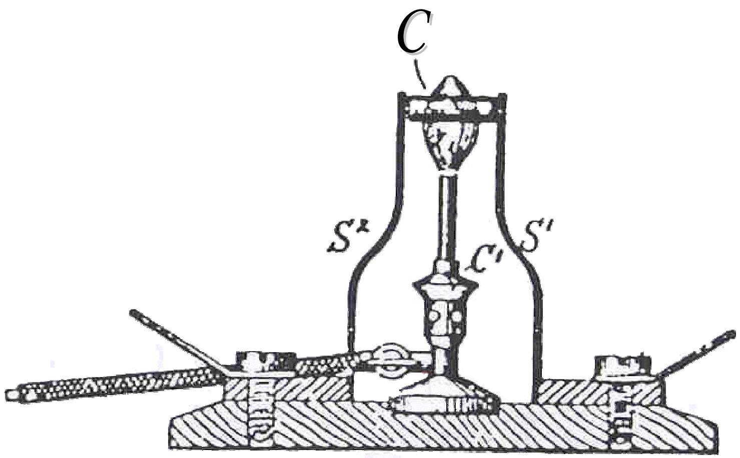
June 3, 2003

National Energy Technology Laboratory
Office of Fossil Energy

SECA CORE TECHNOLOGY PROGRAM



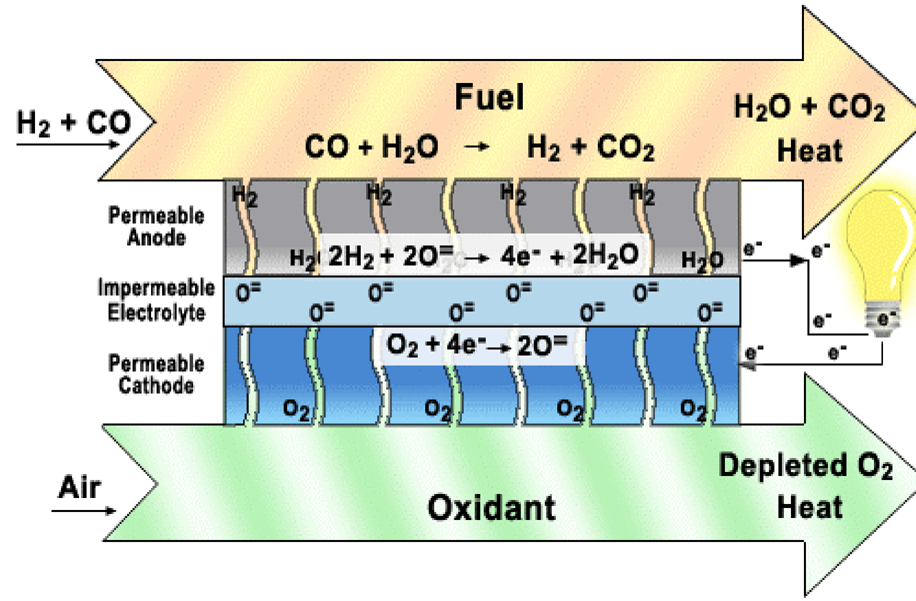
W. Nernst

"Electrical Glow-Light"

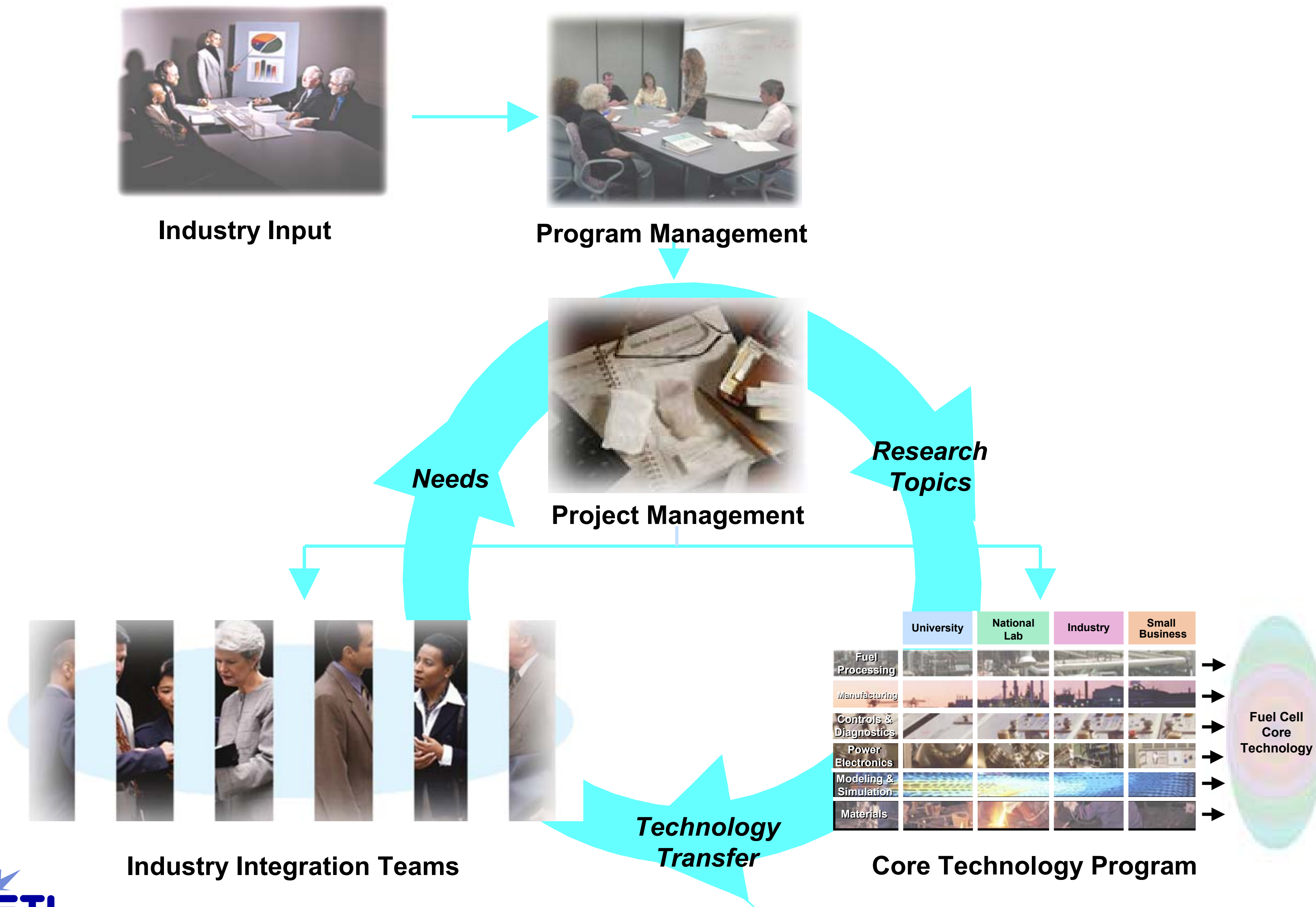
U.S. Patent 623,811

April 25, 1899

Solid Oxide Fuel Cell

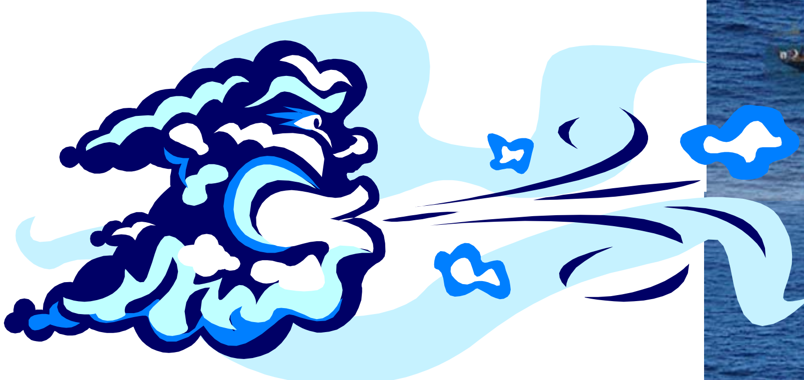


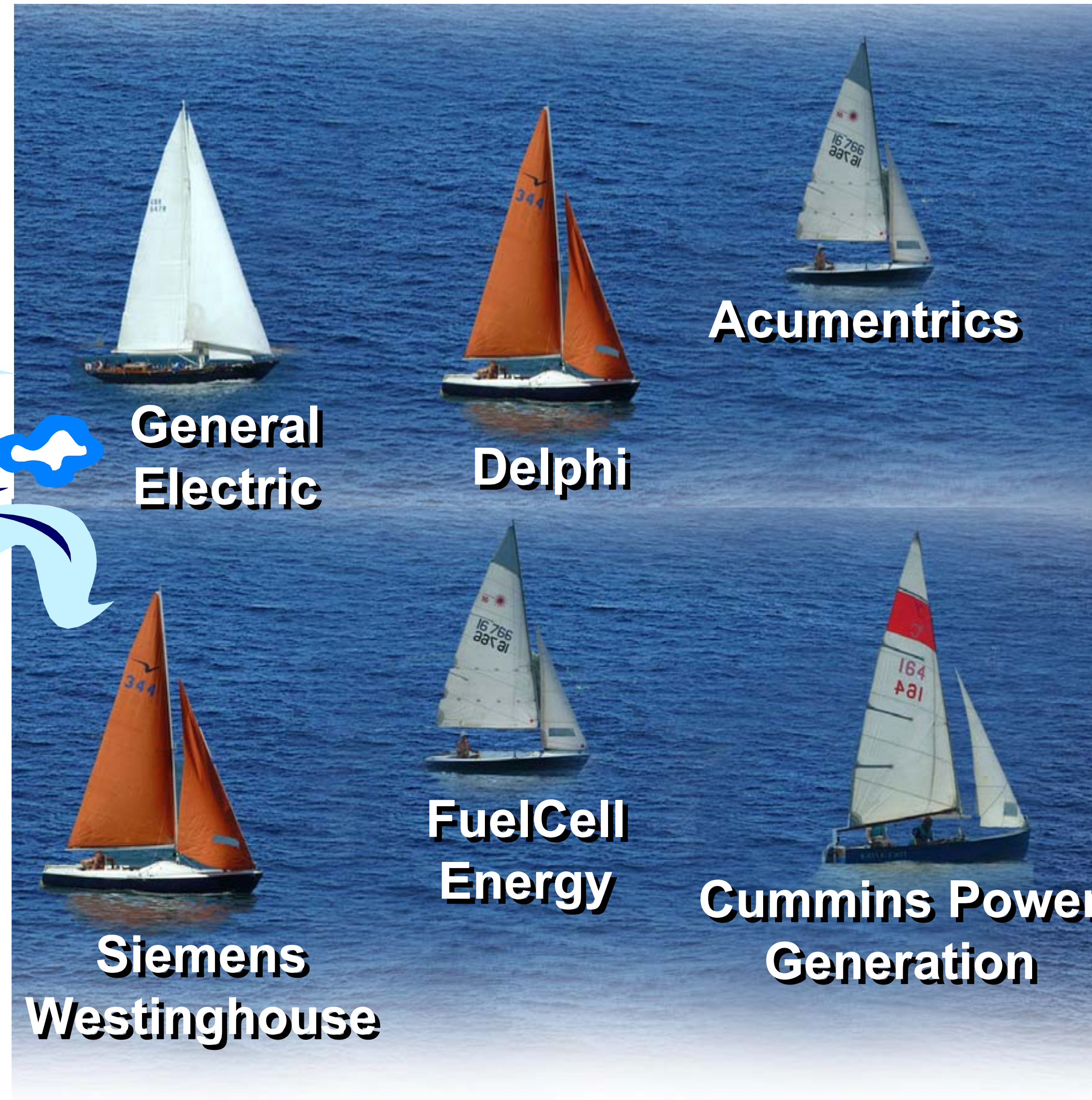
SECA Program Structure



Core Technology Program Powering All Ships

- Materials
- Modeling and simulation
- Fuel processing

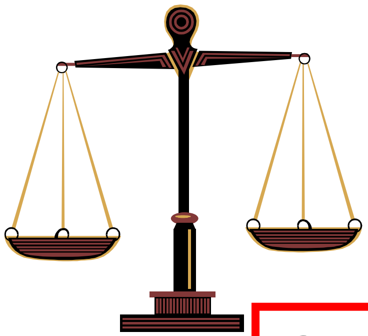




- Power electronics
- Controls and diagnostics
- Manufacturing

NETL

Intellectual Property
Cornerstone of the Alliance



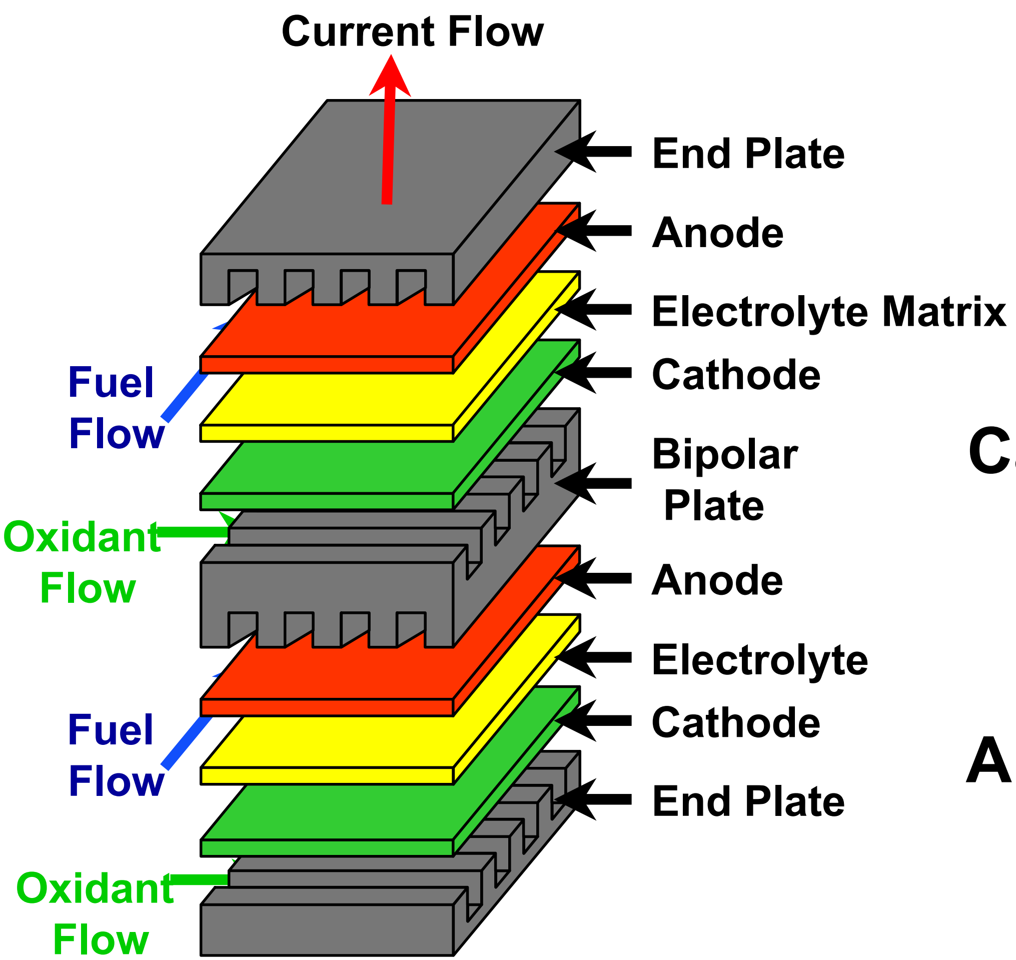
- Non-Exclusive License

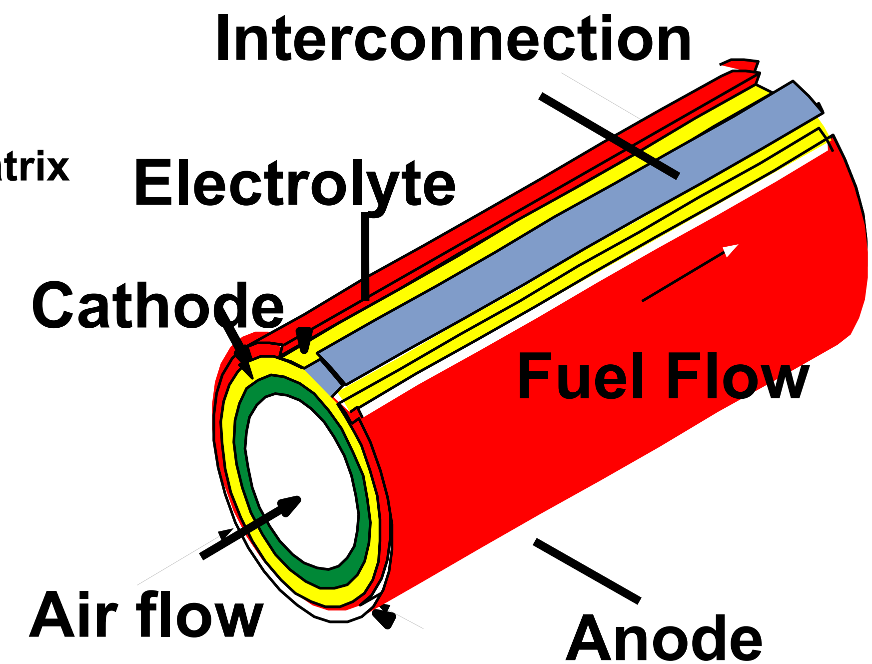
CTP → Industry Teams

  - Open for 1 year after issue of a U.S. patent
  - Ready market of potential licensees
  - Best designs vs. highest bidder
  - Dispute Resolution Mechanism

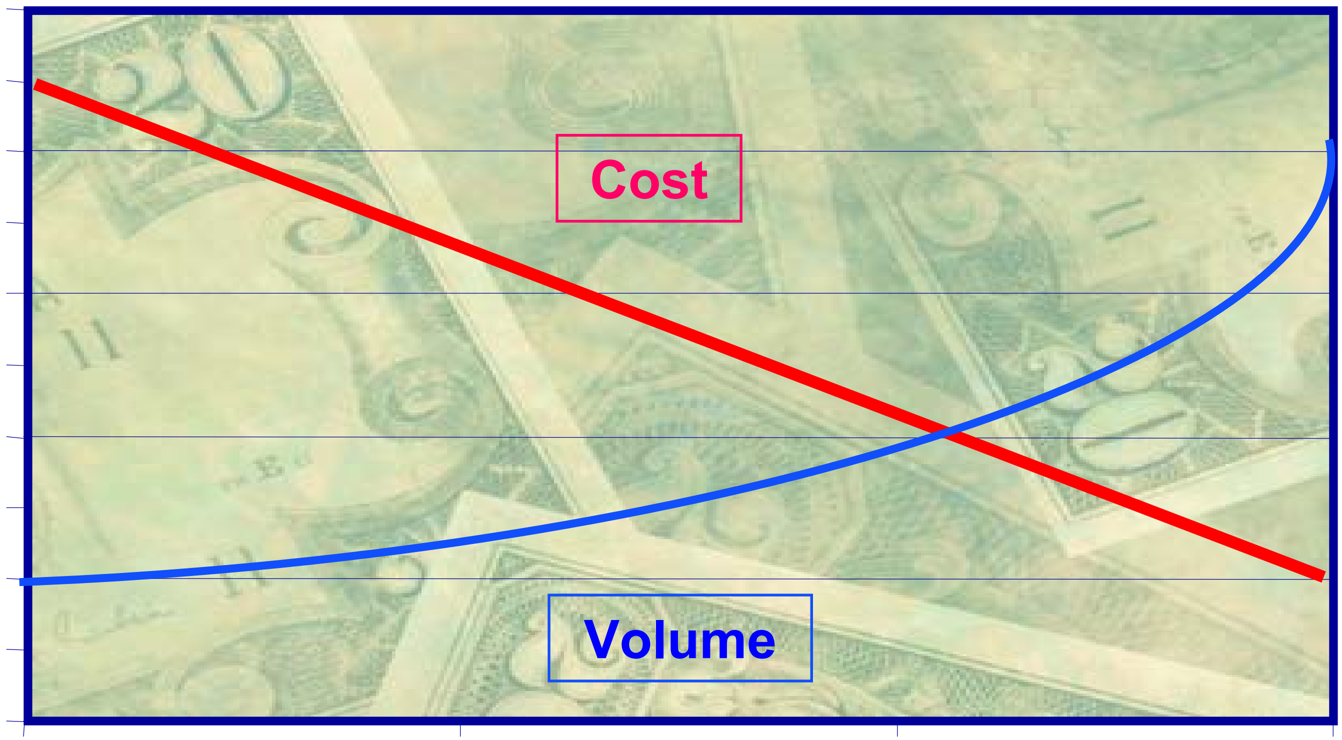
- Promotes Collaboration - Limits Duplication
- Pilot program; reevaluate after 2 years

Solid Oxide Fuel Cell





The Vision: *Fuel Cells in 2010*



Low Cost/High Volume
$400/kW > 50,000 units/yr

NETL

Different Approaches!

Team	*Design*	*Manufacturing*
Cummins-SOFCo	• Electrolyte supported • 850 C • Thermally matched materials • Seal-less stack	• Tape casting • Screen printing • Co-sintering
Delphi-Battelle	• Anode supported • 750 C • Ultra compact • Rapid transient capability	• Tape casting • Screen printing • 2–stage sintering
General Electric Company	• Anode supported • 750 C • Hybrid compatible • Internal reforming	• Tape calendering • 2–stage sintering
Siemens Westinghouse	• Cathode supported • 800 C • Redesigned tubular • Seal-less stack	• Stack extrusion • Plasma spray

Two New Different Approaches!

Team	Design	Manufacturing
Acumentrics Corporation	• Anode supported microtube • 750 C • Thermally matched materials • Robust & rapid start-up	• Extrusion • Dip processing • Spray deposition
FuelCell Energy, Inc.	• Anode supported • < 700 C • Low cost metals	• Tape casting • Screen printing • Co-sintering • Electrostatic deposition

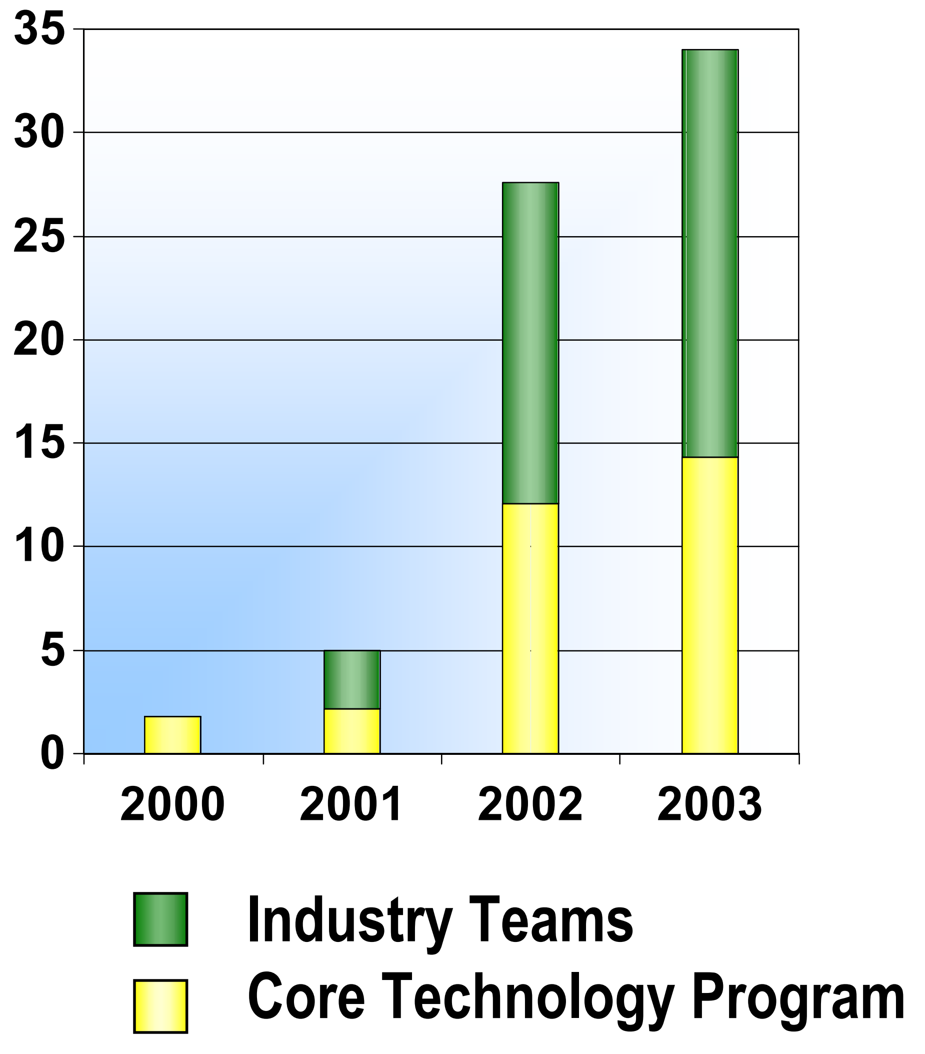
SOFC Materials Costs

SOFC Component	Material Cost ($/kW)
Common Materials (excluding interconnects)	
Ni/ZrO_2 anode (500 microns)	11.67
ZrO_2/Y_2O_3 electrolyte (10 microns)	0.40
$LaMnO_3$ cathode (50 microns)	2.30
ss End Plates (1.25 centimeters)	0.70
Subtotal Common Materials	*15.07*
Ceramic Interconnect (2.5 millimeters)	137.50
Subtotal Ceramic Interconnect & Common Materials	*152.57*
50% Contingency	*76.28*
Total Material Costs Using Ceramic Interconnects	**228.85**
Metallic Interconnect (2.5 millimeters)	6.67
Subtotal Metallic Interconnect & Common Materials	*21.74*
50% Contingency	*10.87*
Total Material Costs Using Metallic Interconnects	**32.61**

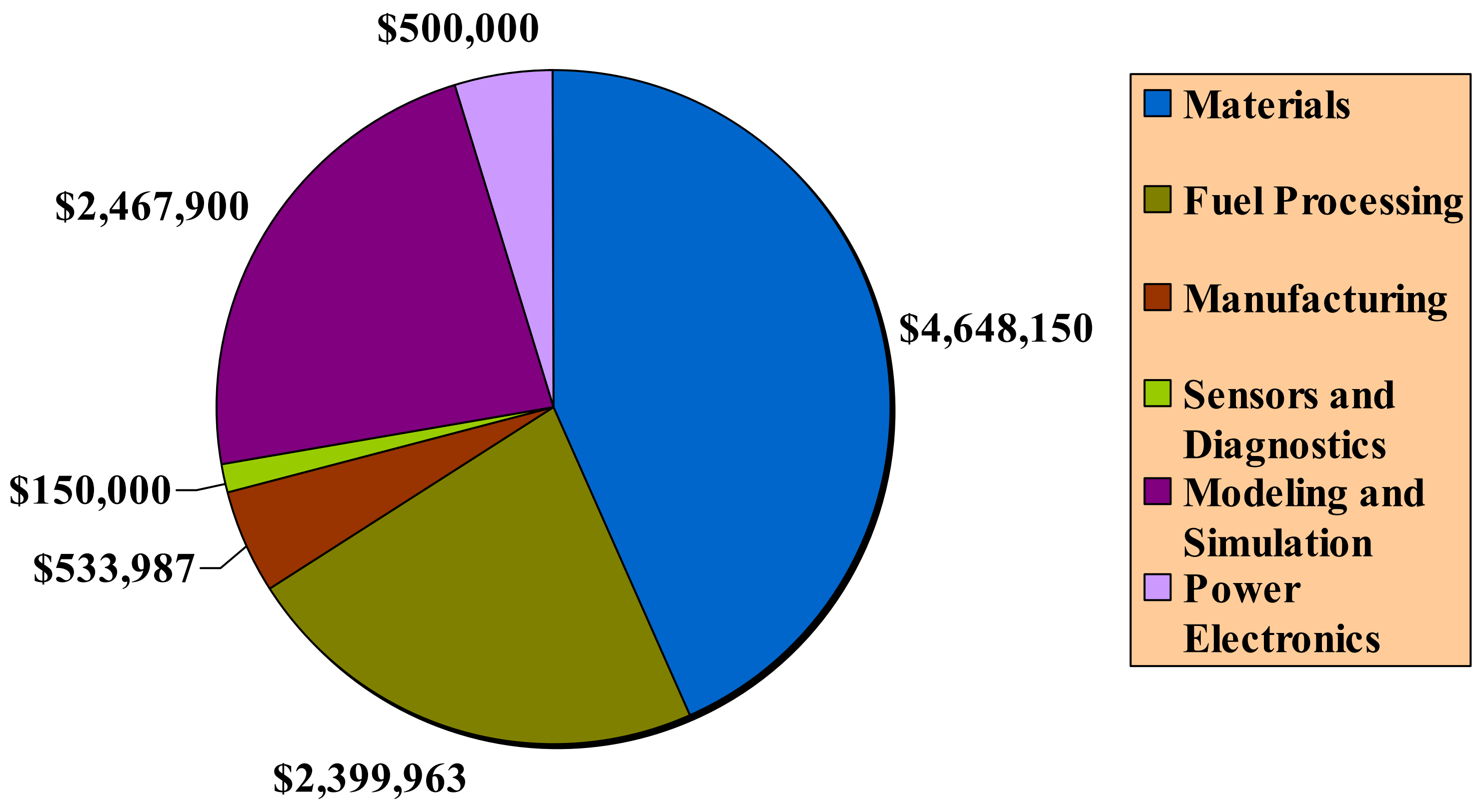
Current Priorities: *Core Technology Program*

1	Gas seals	• Glass and compressive seals
1	Interconnect	• Modifying components in alloys • Coatings
2	Modeling	• Models with electrochemistry • Structural characterization
2	Cathode performance	• Micro structure optimization • Mixed conduction • Interface modification
2	Anode/ fuel processing	• Metal oxides with interface modification • Catalyst surface modification • Characterize thermodynamics/kinetics
3	Power electronics	• Direct DC to AC conversion • DC to DC design for fuel cells
4	Material cost	• Lower cost precursor processing • Cost model methodology

SECA Budget ($M)



Core Technology Program FY 2003

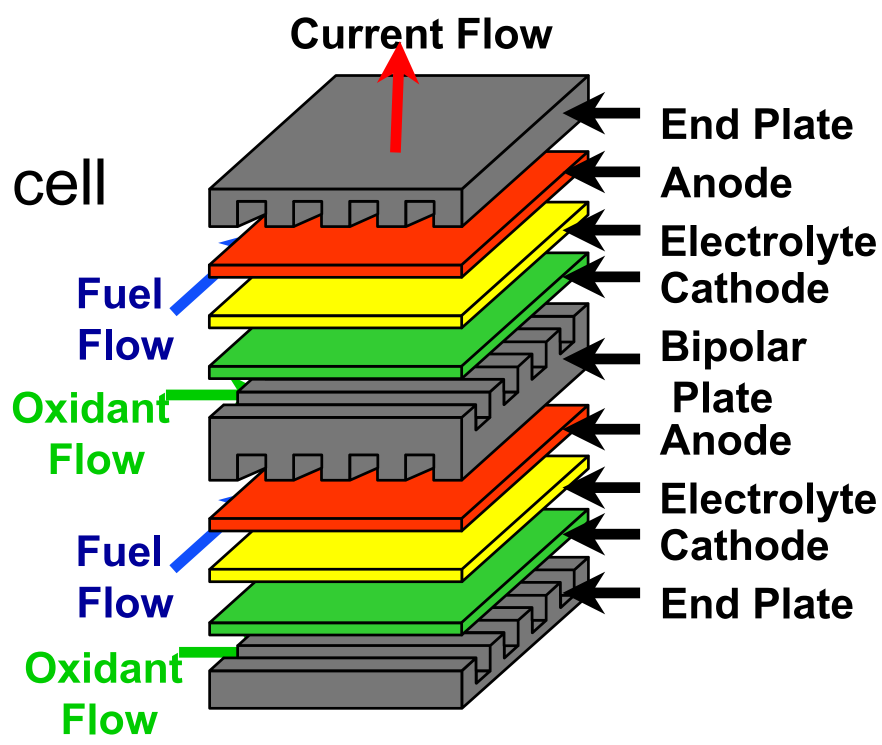


Stack Technology – Seals & Cross Cutting

PNNL – Seals, Modeling and Analysis, Cathodes, Anodes, Interconnects, Fuel Processing

LBNL – Metallic supported cell structure, Cathode interface modification

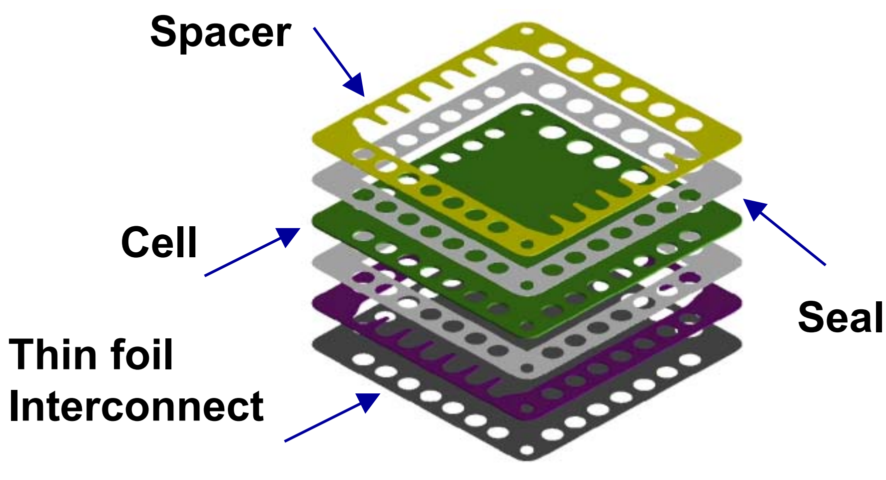
ANL – Metallic supported cell structure, Interconnects, Fuel Processing



Materials - Interconnects

Develop low temperature interconnect suitable for SOFC

- U. of Pittsburgh
- Ceramatec
- Southwest Research Institute
- PNNL
- ANL



Images courtesy of Delphi

Modeling and Simulation

Structural, performance, and optimization design tools

- PNNL
- NETL
- ORNL
- U. of Florida
- Georgia Tech
- TIAX

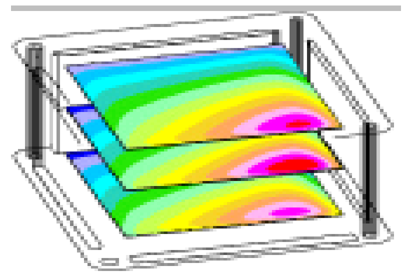


Image courtesy of PNNL

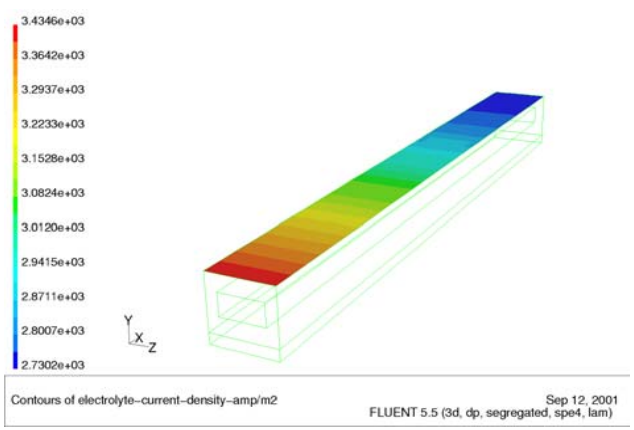
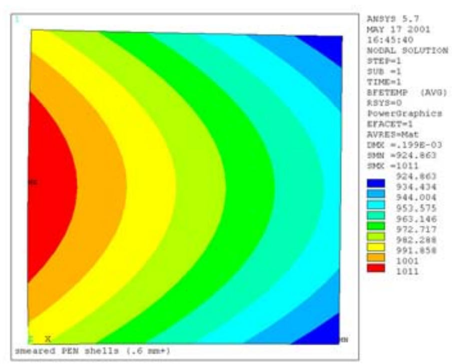


Image courtesy of NETL



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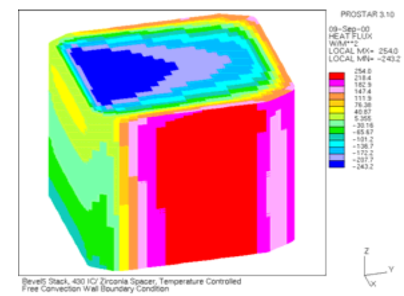
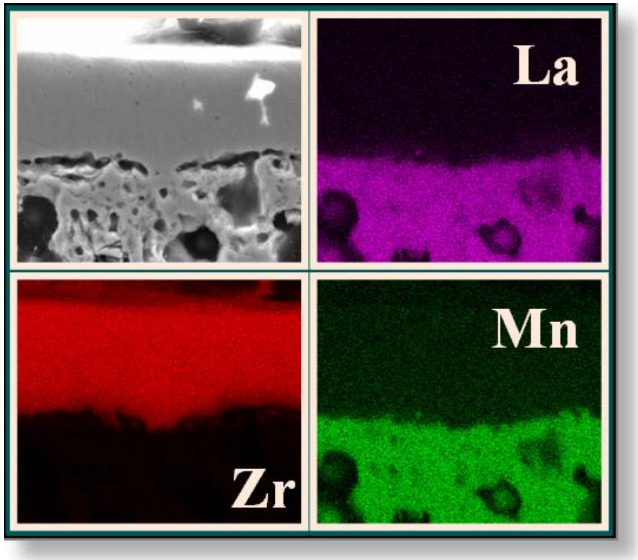


Image courtesy of Delphi

Materials - Cathodes

Cathode performance – 2x improvement

- U. of Washington
- U. of Missouri Rolla
- U. of Utah
- Functional Coating, LLC
- Georgia Tech
- PNNL



Images courtesy of NexTech

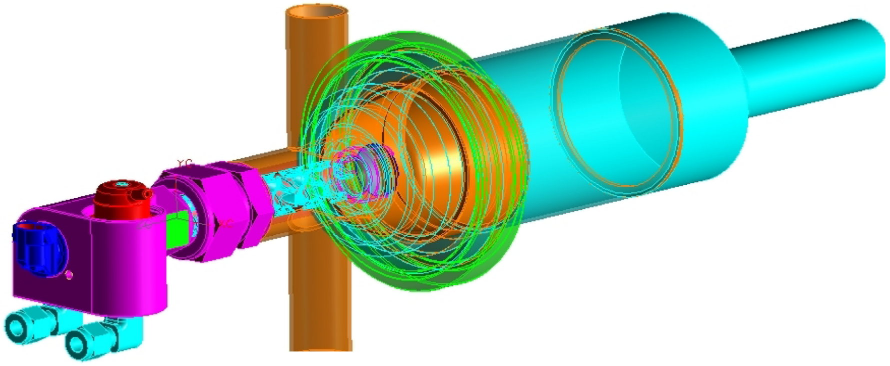
Fuel Processing and Anode Tolerance

Carbon and sulfur resistant anodes

- Northwestern
- GTI

Carbon and sulfur resistant reforming catalysts

- LANL
- ANL
- NETL



Tubular cPox Reformer

Image courtesy of Delphi

Power Electronics / Controls & Diagnostics

Interaction between fuel cell, power conditioning system and application loads

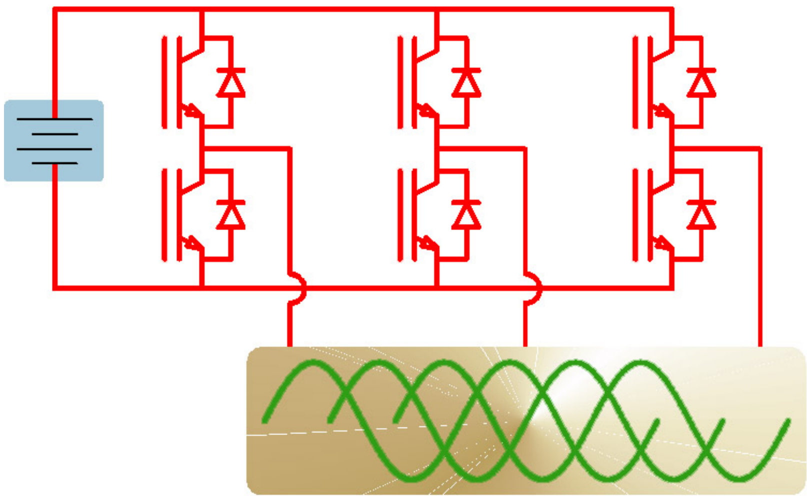
- U. of Illinois

DC-DC / DC-AC converters

- Texas A&M
- Virginia Polytechnic Institute

High Temperature Sensors

- NexTech Materials



Manufacturing

Low cost and consistent precursor materials

- NexTech Materials
- U. of Utah

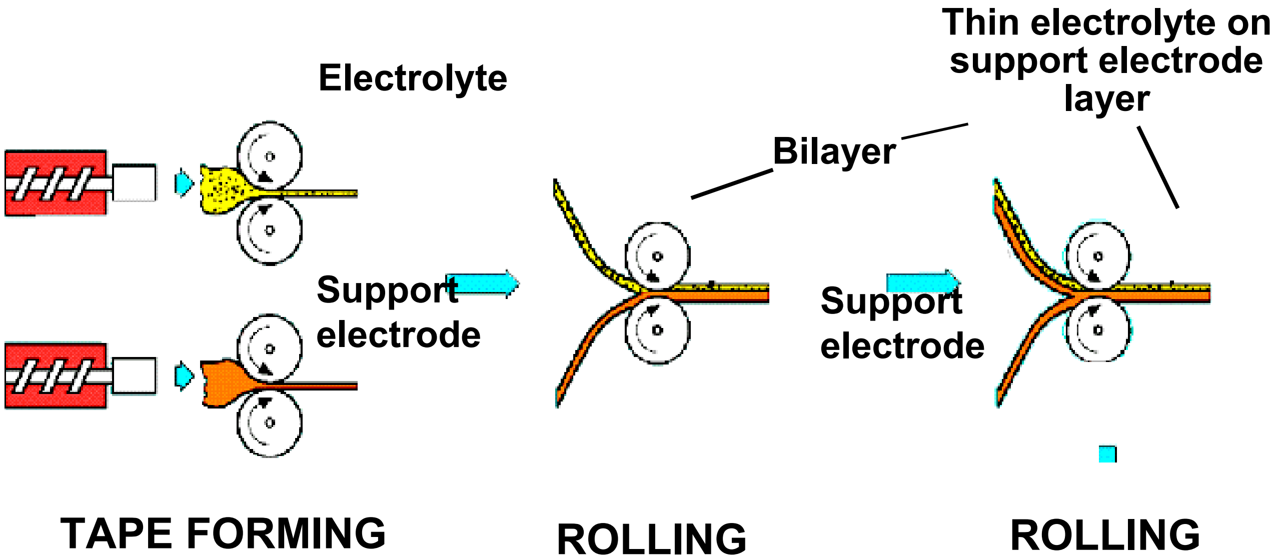


Image courtesy of Honeywell

TAPE CALENDERING