

# NETL Overview



*Direct Carbon Fuel Cell Workshop  
July 30, 2003  
Pittsburgh, PA*

**National Energy Technology Laboratory**



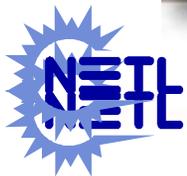
*U.S DOE  
Office of Fossil Energy*



# National Energy Technology Laboratory



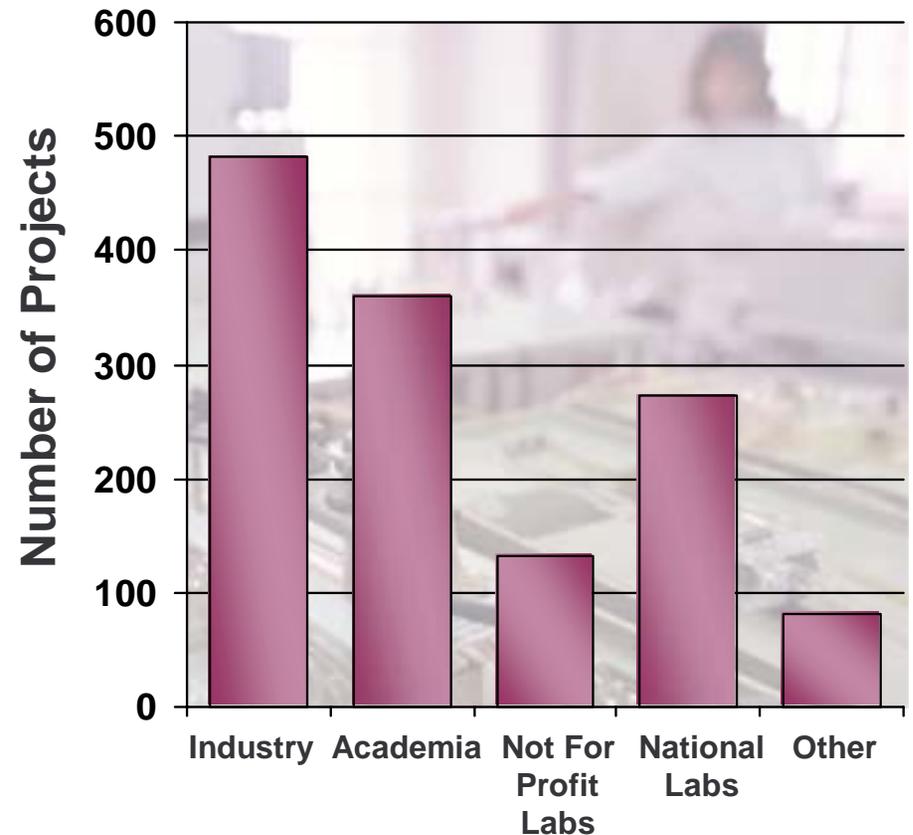
- One of DOE's 17 national labs
- Government owned / operated
- Sites in:
  - Alaska
  - Oklahoma
  - Pennsylvania
  - West Virginia
- More than 1,100 federal and support contractor employees



# Shape, Fund, and Manage Extramural R&D



- **1,300 research activities in all 50 states and several foreign countries**
- **Total award value \$7.3 billion**
- **Private sector cost-sharing of \$3.6 billion**
  - Leverages DOE funding
  - Ensures relevance
  - Accomplishes mission through commercialization



# NETL Product Areas



Innovations for Existing  
Plants

Gasification Technologies

Combustion Technologies

Carbon  
Sequestration

Demonstration Programs  
CCT, PPII, CCPI

Coal Fuels &  
Hydrogen

Vision 21

Fuel Cells

Advanced Turbines

Advanced Research



# DOE Fossil Energy Distributed Generation R&D Program Goals



- Ensure widespread deployment of clean fuel cell technology
- Develop technology that is:
  - Very low cost
  - Widely applicable
  - Highly reliable



# Fuel Cell Program Areas (FY03 Funding)



**SECA - \$34.0MM**

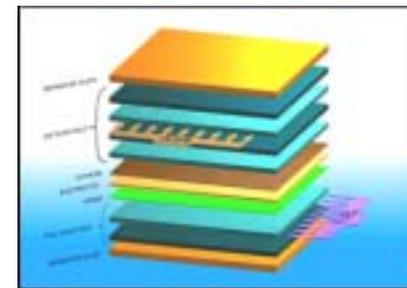


**Molten Carbonate - \$10 MM**

**Advanced Research  
(Electrochemical Engineering)  
\$3.5MM**



**Vision 21 Hybrids - \$13.5MM**

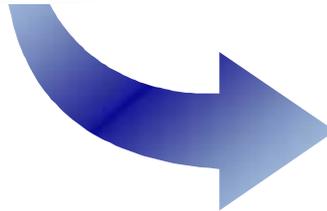


# Molten Carbonate Fuel Cells



## 2002

- Demonstration
- 47% efficiency
- \$2,500-5,000/kW
- 250kW
- Internal reforming
- Torrington, CT manufacturing facility 50MW/year



## 2003-2008

- Near-term DG market
- 54% efficiency
- \$1,000-1,500/kW
- 250kW-3MW



# Tubular Solid Oxide Fuel Cells



## 2002

- 47% efficiency
- > \$10,000/kW
- 100-220kW
- 20,000 hrs operation at 100-kW

## 2003-2008

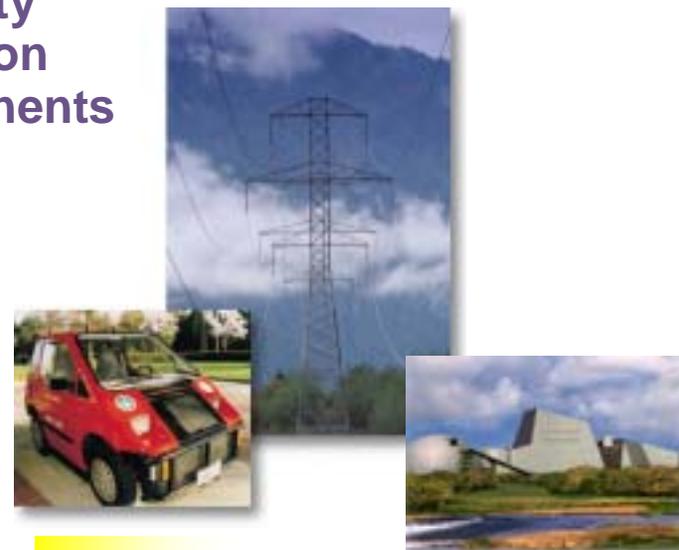
- Near-term DG market
- 47- 63% efficiency
- Munhall, PA 15MW/yr manufacturing facility (\$4500/kW)
- 250kW - 550kW
- \$1,000-\$1,500/kW



# SECA Goals and Applications



Broad Applicability  
Mass Customization  
Core Module Components



**2005**

- **Early Markets**
  - Long-haul trucks
  - RVs
  - Military
  - Premium power
  - Remote Stationary

**2010**

- **\$400/kW**
  - Residential & industrial CHP
  - Transportation auxiliary power

**2015**

- **Vision 21 power plants**
  - 75% efficient
- **Hybrid systems**
  - 60–70% efficient



# SECA INDUSTRIAL TEAMS



FuelCell Energy



**DELPHI** **Battelle**

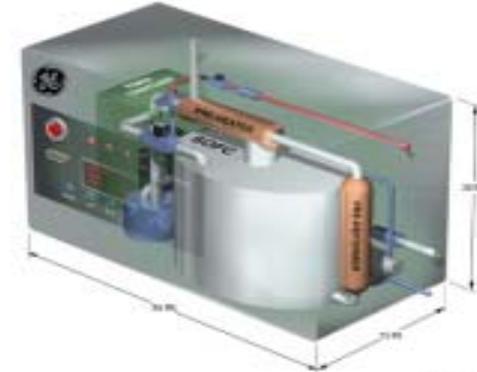
Driving Tomorrow's Technology



Stacks provided by Global Thermoelectric



General Electric Company



**SIEMENS**  
**Westinghouse**



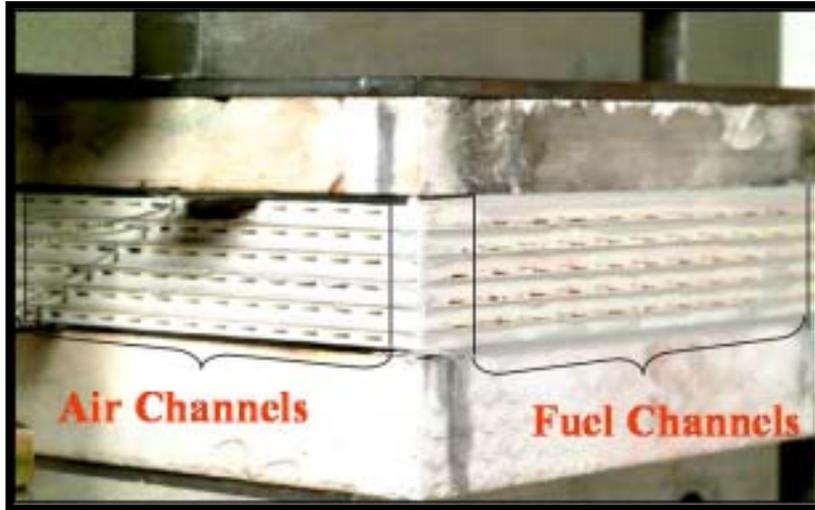
**Acumentrics**  
Advanced Power & Energy Technologies



Power  
Generation



# Cummins - SOFCo



**5-cell Cross-flow Stack**

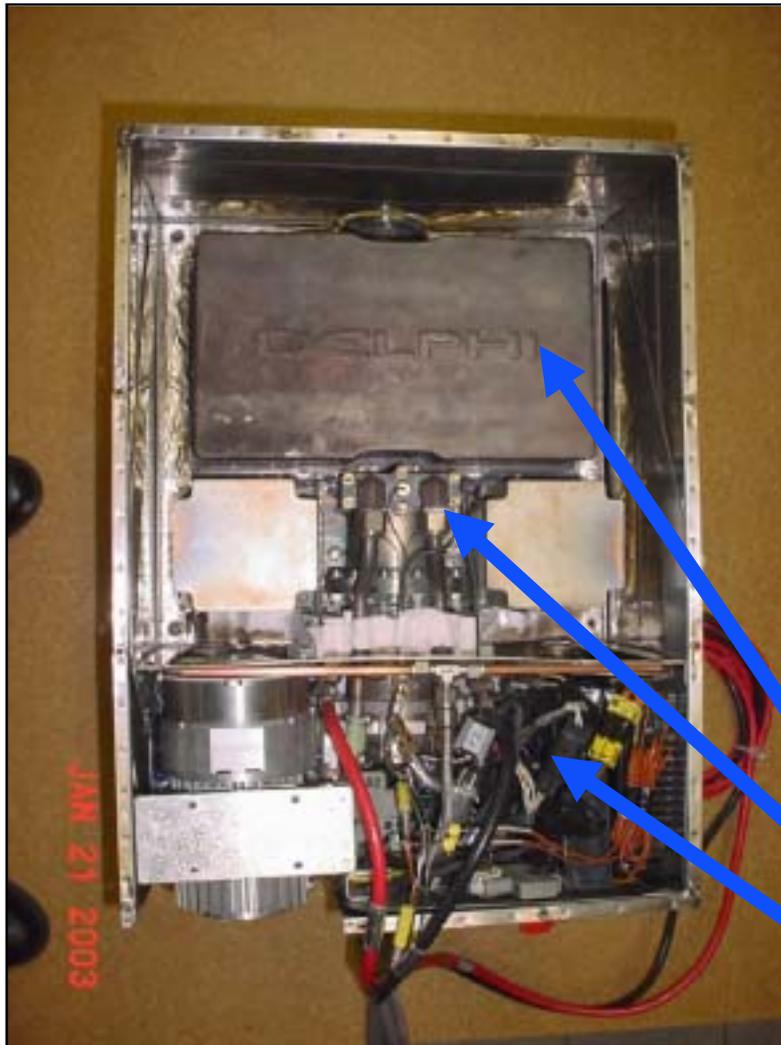
**Catalytic  
Partial  
Oxidation**



**Two 60-cell  
Stacks**



# Delphi - Battelle

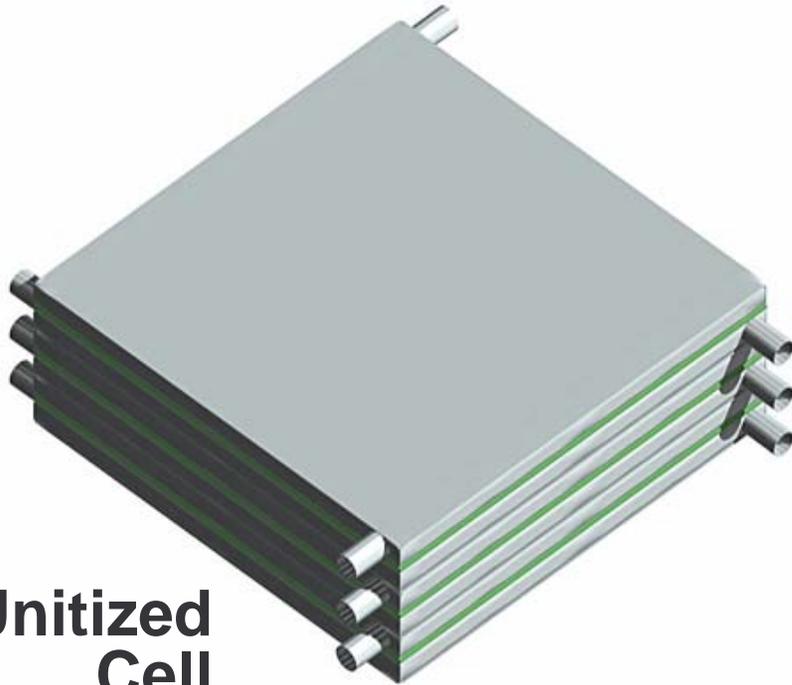


**Compact, light,  
low-cost systems  
for transportation**

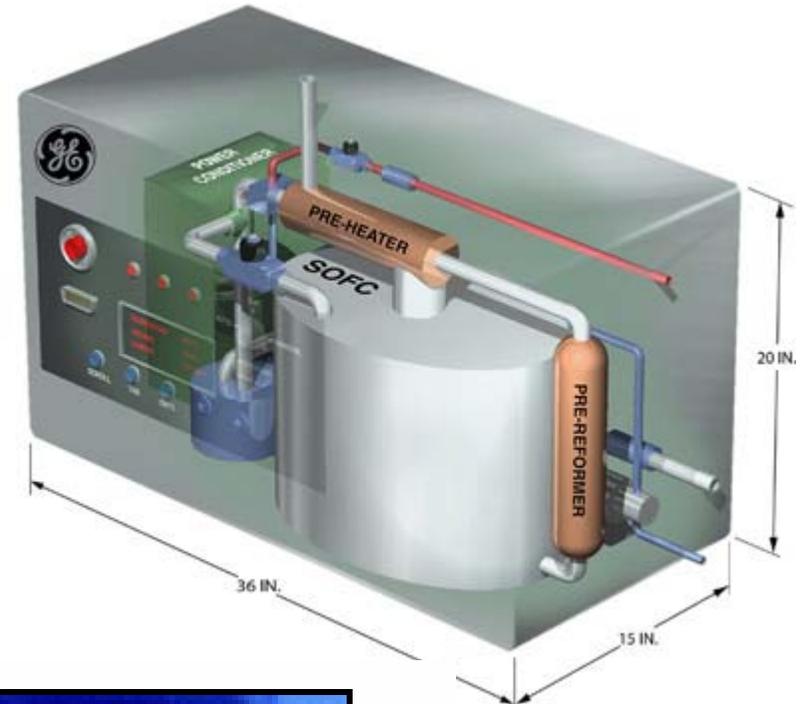
- Generation 2 APU**
- Two 15-cell stacks**
- ReforWER**
- Balance of Plant**



# General Electric

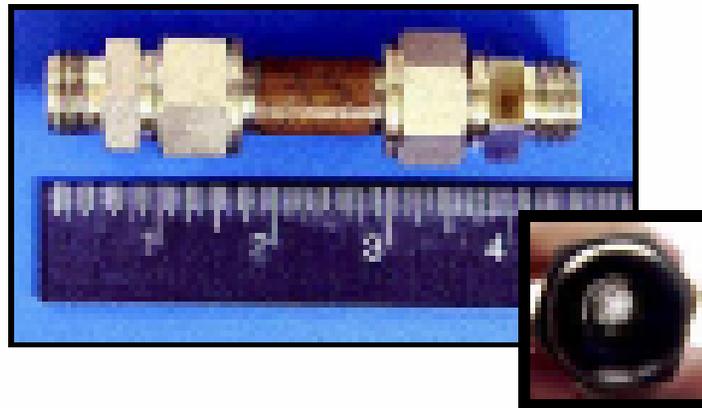


**Unitized  
Cell  
Design**



**Conceptual  
Design**

**1-kW Catalytic  
Partial Oxidation**



# Siemens Westinghouse



5 kW  
Prototype



Redesigned Tube

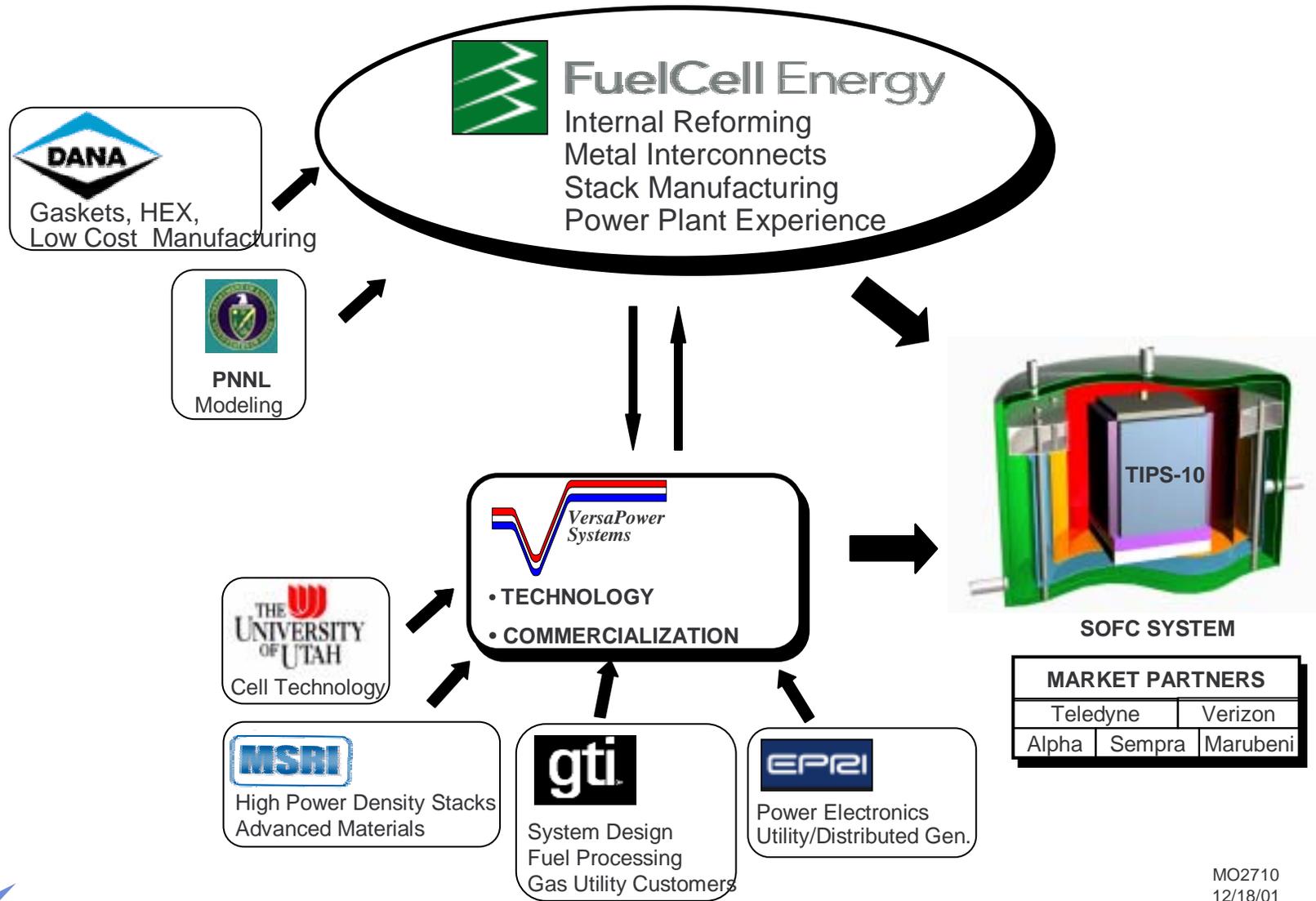


Tubular  
cell



# FCE-VPS Team Members

VPS is the joint venture between FCE, GTI, EPRI, MSRI and UU

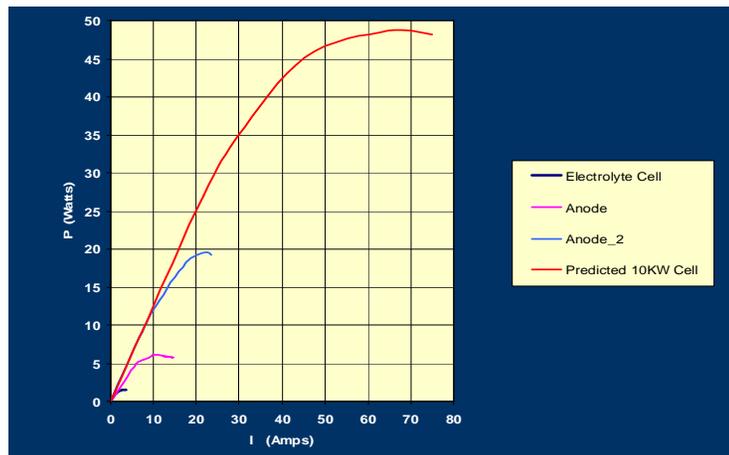


# Acumentrics



## Anode supported Tubular SOFC Systems

- 45 minute start-up
- Excellent cycle capability
- Excellent load following
- Low pressure gas feed
- Direct in-cell reforming



**5,000 Watt**

APU Core Module



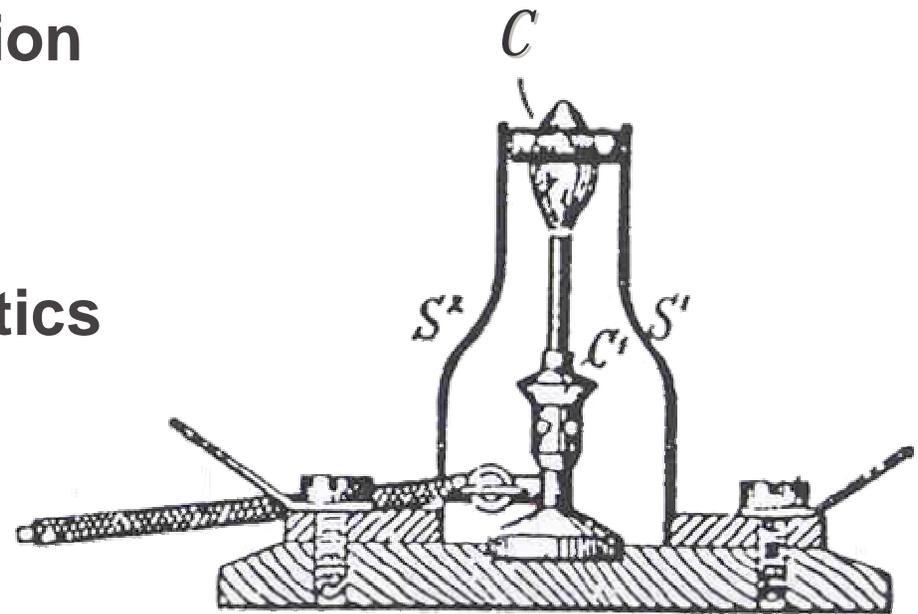
Q4 - 2002



# SECA Core Technology Program



- Materials
- Modeling and simulation
- Fuel processing
- Power electronics
- Controls and diagnostics
- Manufacturing



W. Nernst  
"Electrical Glow-Light"  
U.S. Patent 623,811  
April 25, 1899

# Current Priorities: *Core Technology Program*



	<b><i>What</i></b>	<b><i>How</i></b>
1	<b>Gas seals</b>	<ul style="list-style-type: none"><li>• Glass and compressive seals</li></ul>
1	<b>Interconnect</b>	<ul style="list-style-type: none"><li>• Modifying components in alloys</li><li>• Coatings</li></ul>
2	<b>Modeling</b>	<ul style="list-style-type: none"><li>• Models with electrochemistry</li><li>• Structural characterization</li></ul>
2	<b>Cathode performance</b>	<ul style="list-style-type: none"><li>• Micro structure optimization</li><li>• Mixed conduction</li><li>• Interface modification</li></ul>
2	<b>Anode/ fuel processing</b>	<ul style="list-style-type: none"><li>• Metal oxides with interface modification</li><li>• Catalyst surface modification</li><li>• Characterize thermodynamics/kinetics</li></ul>
3	<b>Power electronics</b>	<ul style="list-style-type: none"><li>• Direct DC to AC conversion</li><li>• DC to DC design for fuel cells</li></ul>
4	<b>Material cost</b>	<ul style="list-style-type: none"><li>• Lower cost precursor processing</li><li>• Cost model methodology</li></ul>



## Direct Carbon Fuel Cell Projects



- **Direct Carbon Conversion Fuel Cell – John Cooper, Lawrence Livermore National Laboratory (FY03 - \$80k)**
- **University Coal Research – Innovative Concepts Projects (1yr - \$50k each):**
- **V2O5-Pt Catalyst for Carbon Oxidation in DCFCs – Steven Chuang, University of Akron**
- **Carbon Ionic Conductors for use in Novel Carbon-Ion Fuel Cells – Hadley Cocks and Neal Simmons, Duke University**
- **Spouted Bed Electrodes for DCFCs – Joseph Calo, Brown University**
- **Modeling and Design for a DCFC with Entrained Fuel and Oxidizer – Alan Kornhauser, Virginia Tech**





A screenshot of a Microsoft Internet Explorer browser window displaying the website for the National Energy Technology Laboratory's Strategic Center for Natural Gas. The browser's address bar shows the URL "http://www.netl.doe.gov/scng/index.html". The website header features the NETL logo on the left and the DOE logo on the right, with the text "NATIONAL ENERGY TECHNOLOGY LABORATORY STRATEGIC CENTER FOR NATURAL GAS" in the center. A navigation menu below the header includes links for "Home", "Welcome", "Search", "Site Index", and "Feedback". The date "November 17, 2002" is displayed in the top right corner. The main content area is titled "The Strategic Center for Natural Gas" and includes a sub-header "Integrating All Elements of DOE's Natural Gas Research From Borehole to Burner Tip". A central graphic shows a circular flow of research areas: Strategic Planning &amp; Policy Support, Exploration and Production, Transmission, Distribution &amp; Storage, Gas Processing &amp; End Use, and Energy Conservation. Three news items are listed on the left: "New Drilling System a Lightning Fast Computer Network", "New Projects to Develop 'Deep Trek' Drilling Systems", and "New SECA Research Projects". A "SIGN UP FOR THE SCNG NEWS" button is located at the bottom right of the main content area. A vertical sidebar on the left contains a "What's New" section with links to "SCNG News", "Events", "Overview", "Key Initiatives", "Strategy", "Exploration", "Distribution", "End Use", "Conservation", "Projects", "Ref. Shelf", "Links", and "Contacts".

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- **NETL Mission: Resolve the environmental, supply, and reliability constraints of producing and using fossil resources**
- **Shape, fund, and manage extramural R&D**
- **Conduct onsite research**
- **Support energy policy development**



## Highlights: *Core Technology Program*



- Glass and mica compressive seal characterization
- Inexpensive Ferritic alloy interconnect characterization
- Fuel cell models available
- Material structural characterization
- Mixed conducting cathodes, LaSrFeOx
- Cathode microstructure optimization
- Cathode mechanism intermediates identified
- Metal oxide anode material—promising S, C,O tolerance
- Low temperature bi-layer and ultra-thin electrolytes
- Efficient DC-DC converter designed
- Developing lower cost consistent materials



# OST Focus Areas



## Gas Energy System Dynamics

- Fuel Cells/Hybrids; Gas Combustion

## Vision 21 ---

## Advanced Energy Systems

## Carbon Sequestration

- Capture, Storage, MMV

## Advanced Fuel Systems

- Hydrogen

## Computational Energy Science

- Modeling and Simulation; Gas Hydrates

## Environmental Science

- Clean Air Technology; Water & Coal Utilization Byproducts

