DOE FE Distributed Generation (DG) Systems Program

EPSCOR Workshop

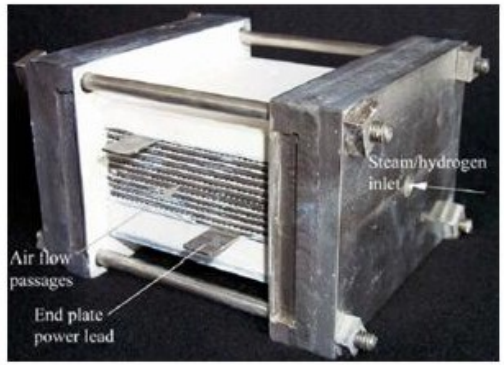
Morgantown, WV
June 16, 2005

Dr. Mark C. Williams, Technology Manager
National Energy Technology Laboratory

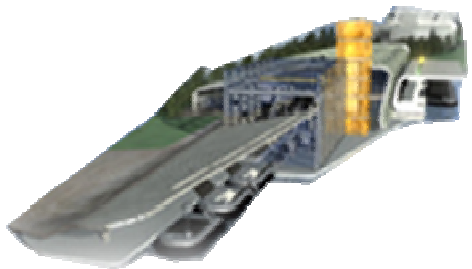
DG Systems Program Areas (R&D Activity)

FY05 Budget in Millions

Innovative Concepts SECA $54.2



Advanced Research $12.2
High Temperature Electrochemistry Center (HiTEC)

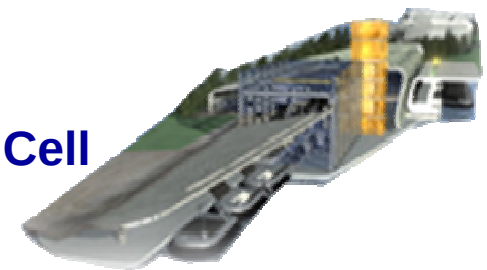


Coal-based Central Systems – Hydrids - $5.0MM

DG Systems Strategy: SECA → Fuel Cell Coal-Based Systems

Fuel cell technology demonstrated in DG applications before use in large-scale Central Power Systems

- **Mass customization through SECA DG applications**
  - High-volume
  - Establish manufacturing and materials base
- **Scale-up SECA-derived fuel cell technology in the form of fuel cell and/or fuel cell-turbine hybrid systems to MW-class**
  - Scale-up
  - Pressurization
  - Aggregation
  - Integration
- **Apply fuel cell-based designs to >100-MW class Fuel Cell Coal-Based Systems**
  - FutureGen
  - Advanced coal-based generation



Key DG Program Milestones (FY)

Coal --- Red

FutureGen --- Blue

SECA/Fuel Cell Coal-Based Systems --- Black

- 2005 Initial SECA prototypes
- 2005 Select Fuel Cell Coal-Based Systems Teams
- 2008 Aggregatable fuel cell stack test on coal gas
- 2010 SECA $400/kW modules
- 2010 MW-class (>250-kW) aggregated, $400/kW fuel cell module test on coal gas at NETL/PSDF
- 2011-2015 MW-class scaleable fuel cell or fuel cell /hybrid on coal at 50% HHV efficiency at FutureGen (Testing FY2013-2015)
- 2018-2020 Test MW-class hybrid system on coal at 60% efficiency (CCPI)
- 2020 100 MW-class fuel cell systems

SECA Industry Teams

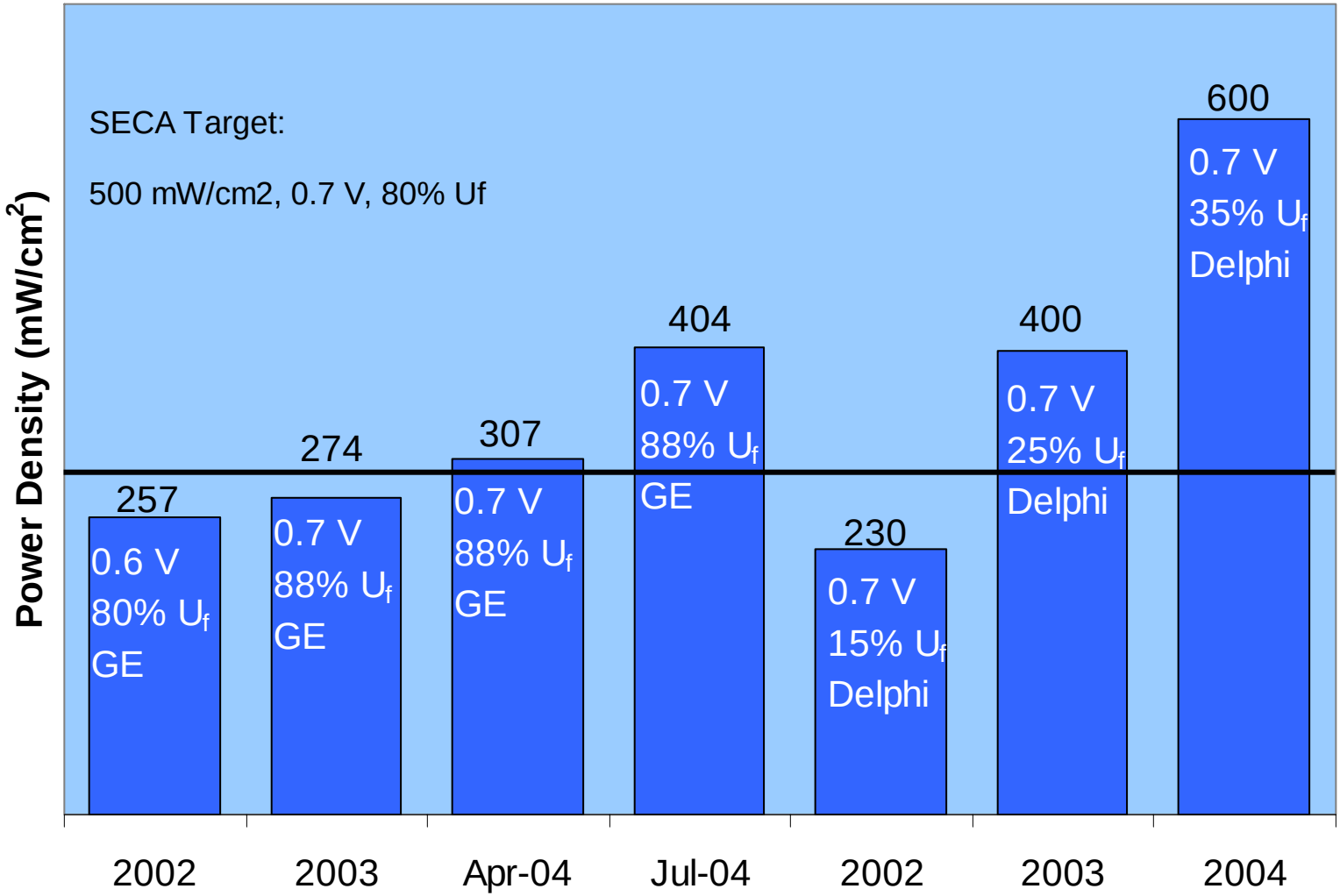
Testing and evaluation of Phase I prototypes for minimal technical requirements is critical for meeting long-term cost and performance targets

Delphi's Phase I prototype qualification testing is scheduled for completion at the end of December 2005.

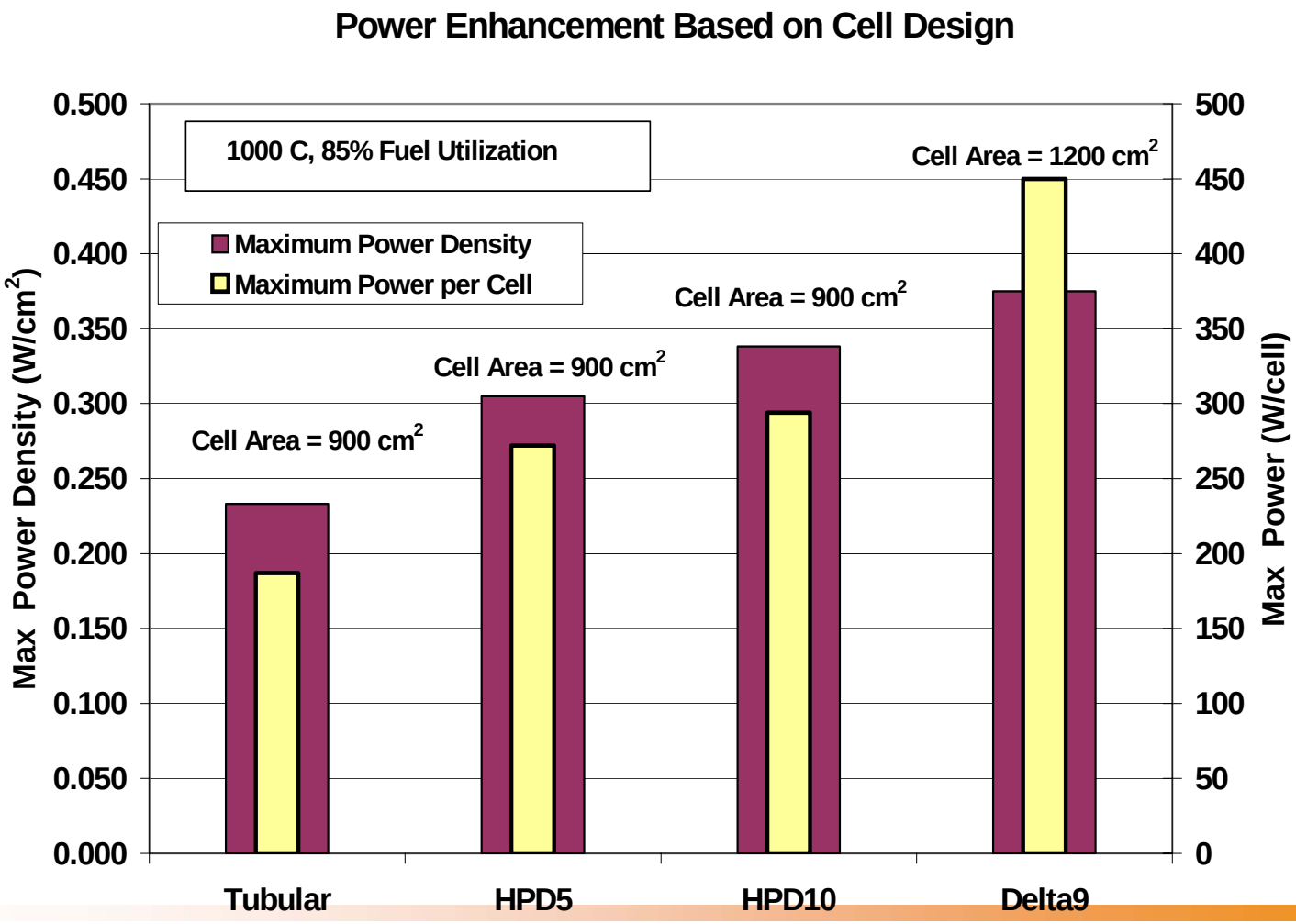
GE's Phase I prototype qualification testing is scheduled for completion at the end of September 2005.

- Acumentric's Phase I prototype qualification testing is scheduled for completion at the end of January 2006
- Cummins' Phase I prototype qualification testing is scheduled for completion at the end of December 2005.
- FCE's Phase I prototype qualification testing is scheduled for completion at the end of February 2007.

Single Cell Module Performance Improvement GE & Delphi

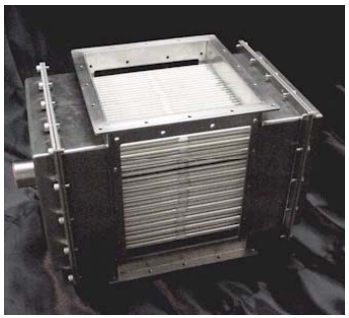


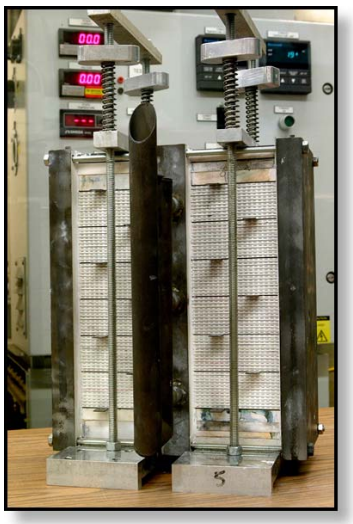
SWPC Maximum Power Density Comparison



SECA Industry Teams

SECA Industry Team Progress and Commitment



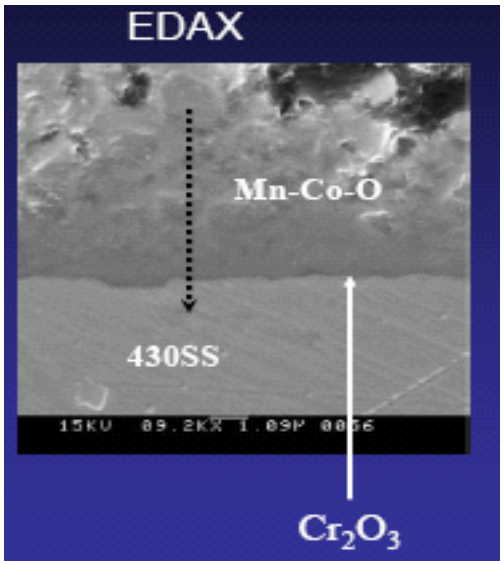


- Acumentric's manufacturing costs may be much lower than some previous fuel cell technologies
- Cummins' may qualify there SECA Project as pilot in VPI program.
- VPS's progress accelerated with incorporation of former Global technology and manufacturing capability

Innovative Concepts – SECA Core

Building on Accomplishments

Collaborative system design improvements and technology transfer will help to meet the Phase I cost and performance targets outlined in solicitation. CTP transferred technology helping to solve seals, interconnects, electrodes, fuel processing, etc.



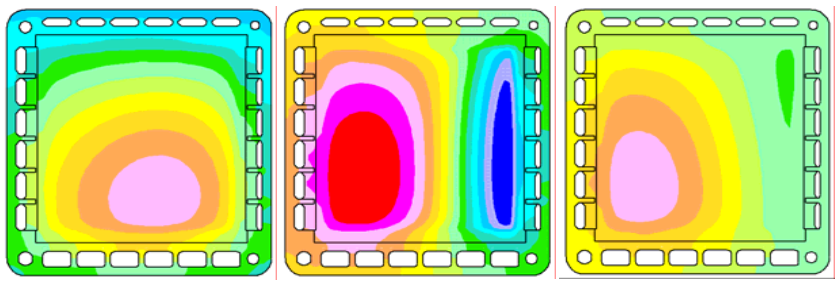
- Determined location and form of Cr deposition and migration in SOFC cathode compositions (PNNL and ANL) Cr Workshop held to formulate a plan to investigate Cr interactions
- FEM based multi-physics MARC code enhanced by GUI - incorporates materials, electrochemistry and empirical flow modules (PNNL and MSC Software) – PNNL reporting results in short course.
- Seal Workshop resulted in a much larger set of seal concepts in development.
  - Mica seal and glass seal composition developed meeting leakage and thermal cycle requirements (PNNL).

Key Core Program Accomplishments

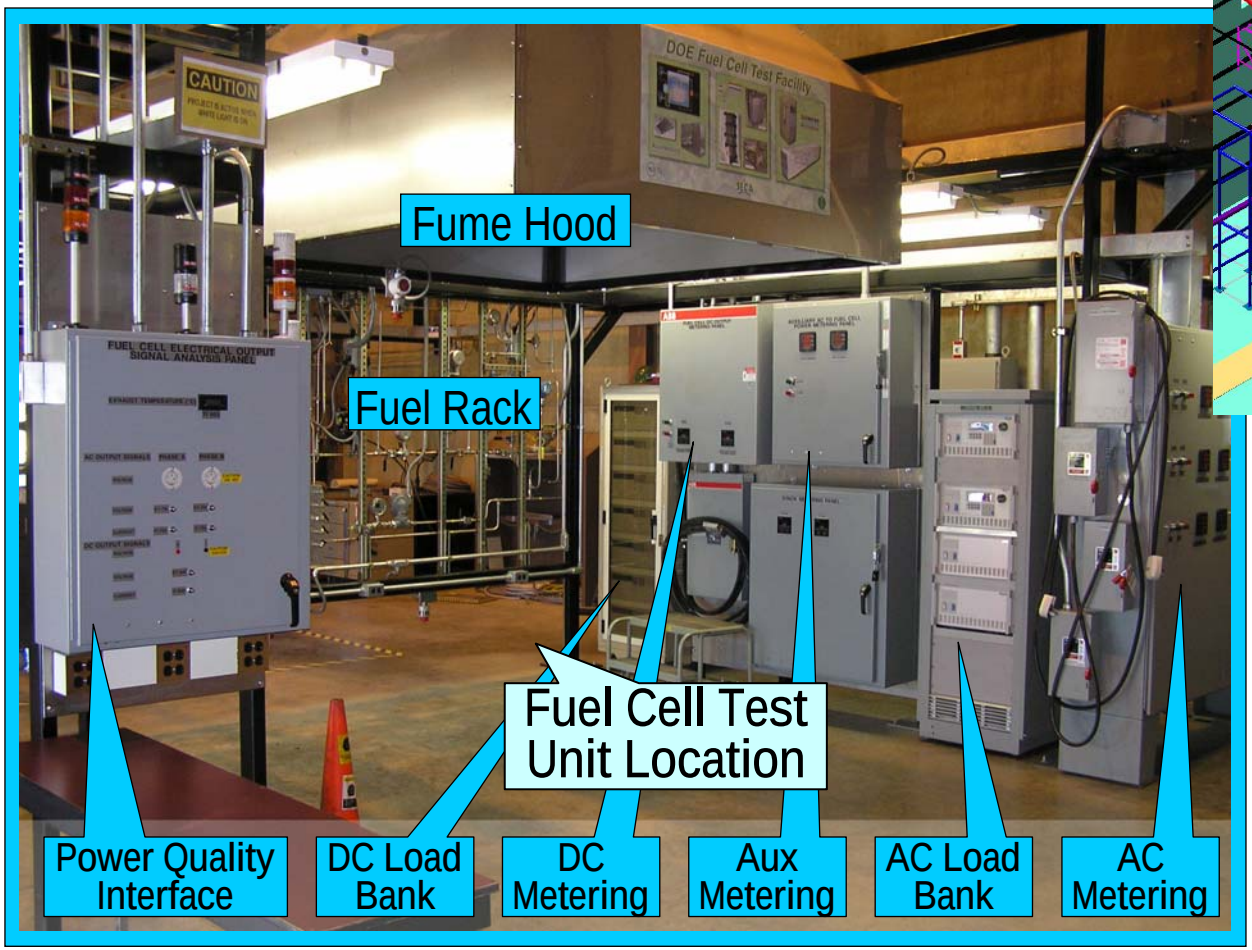
- **Key results**
  - Cathode materials developed permitting 575mW/cm2 @ 0.7 volts in a 30 cell, 106cm2 cell stack (PNNL).
  - Sulfur, carbon and oxygen tolerant anode developed. Performance requires improvement (PNNL).
  - Power electronics/Inverter package – 98% efficient, undergoing tech transfer (Virginia Tech)
  - Available for licensing
  - Integrated SOFC/power electronics integration software, undergoing tech transfer (U. of Illinois)
    - Includes BOP, SOFC, PE – dynamic model for load transients to develop control strategies for any application

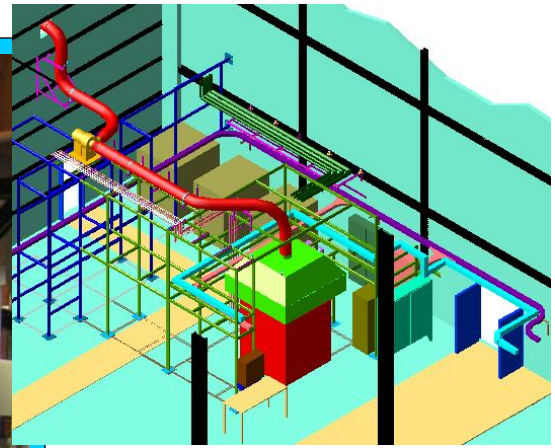
SOFC Material Testing

On-Cell Steam-Methane Reforming



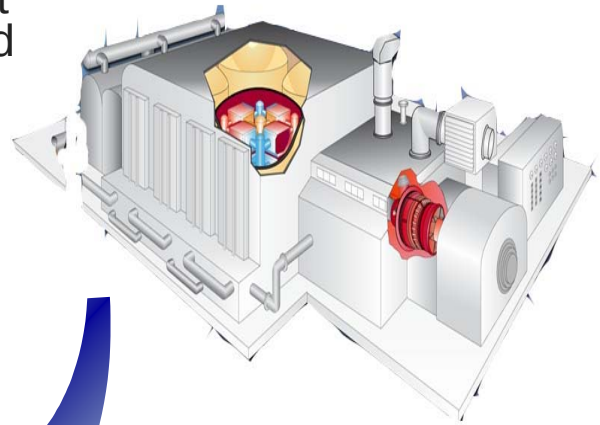
NETL Fuel Cell Test Facility

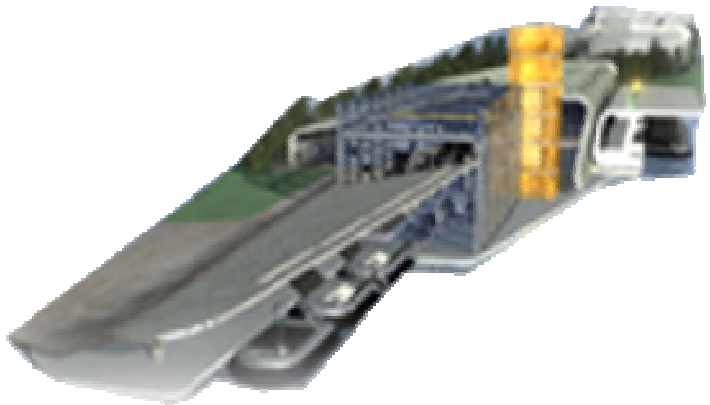




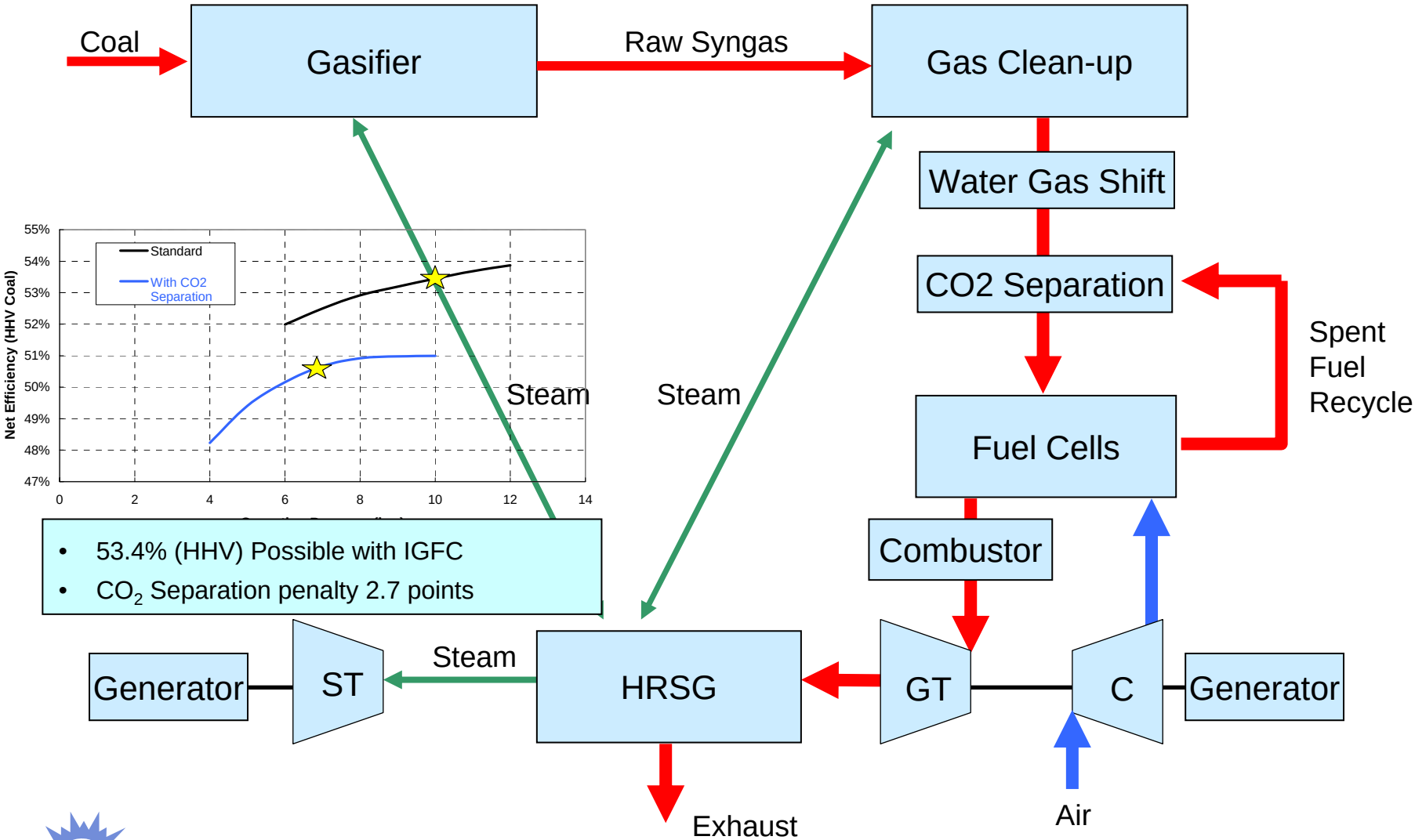
Innovative Concepts – Fuel Cell Coal-Based Systems (FCCBS)

- **SECA Fuel Cell Coal-Based Systems (FCCBS)**
  - Issued a new Fuel Cell Coal-Based Systems solicitation and make selections
  - MW-class SECA fuel cells and hybrids will help meet efficiency, cost, and emissions targets for coal-based power plants
- $5MM Solicitation **(2005)**
- Make selections and negotiate two awards **(4Q/05)**



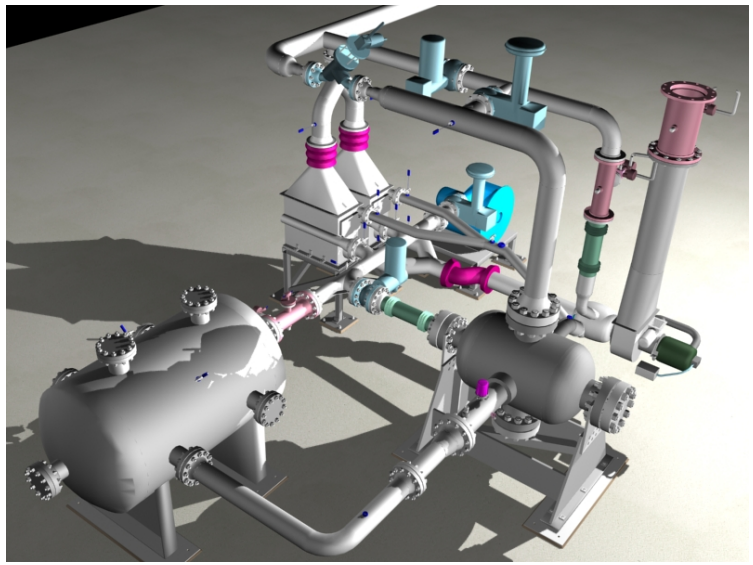


GE Coal Study: Block Diagram



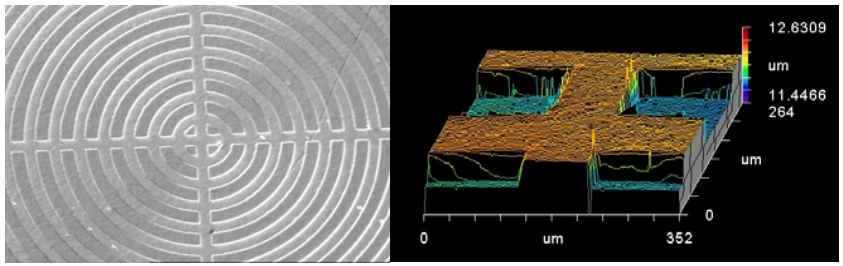
- 53.4% (HHV) Possible with IGFC
- CO_2 Separation penalty 2.7 points

Hybrid Performance (Hyper) Test Facilities at NETL



Advanced Research - High Temperature Electrochemistry Center (HiTEC)

Located at Pacific Northwest National Laboratory (PNNL) with Satellite Universities, currently Montana State University and University of Florida.



Novel electrode structures allow role of microstructure and catalytic activity to be distinguished.

GOALS:

Develop energy storage technologies for coal-based central power plants

Enable load leveling and peak load electricity supply capabilities

Make use of thermoelectric power when coupled with high-temperature power generation units

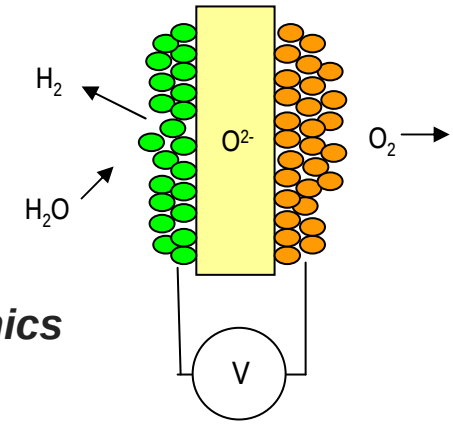
Mission

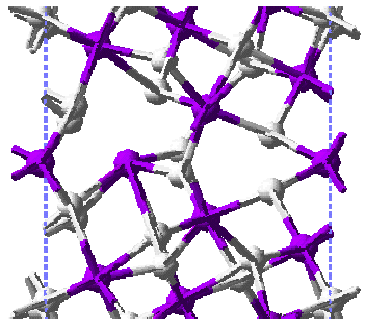
- To advance the solid oxide technology, such as solid oxide, high temperature electrolyzers, reversible fuel cells, energy storage devices, proton conductors, etc., for use in DG and FutureGen applications, and
- To conduct fundamental research that aids the general development of all solid oxide technology.

HiTEC Participants and Projects

"Reversible" solid oxide fuel cell could produce hydrogen from water during periods of excess grid capacity, and produce electricity later from the stored hydrogen.

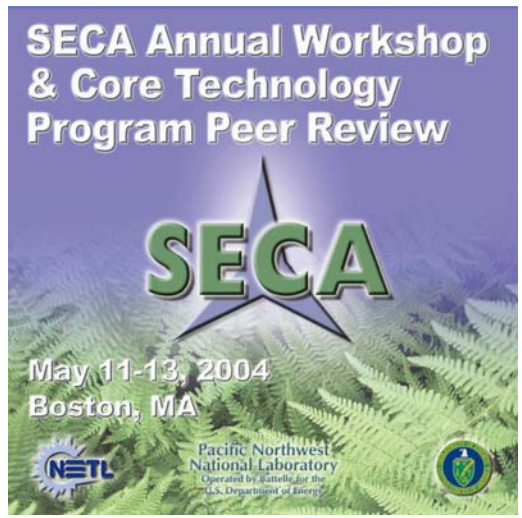
- **Pacific Northwest National Laboratory**
  Reversible Solid Oxide Fuel Cells
- **Montana State University**
  Study of Buried Interfaces in Fuel Cell Structures
  Development of Corrosion-Resistant Layers on SOFC Interconnects
- **University of Florida**
  Proton Conductors/Hydrogen Membranes
  Atomistic modeling of defects using molecular dynamics
- **University of Utah**
  Determination of Cathodic Inefficiencies in SOFCs Using Patterned Electrodes
  Ultra High Power Density SOFC Concepts





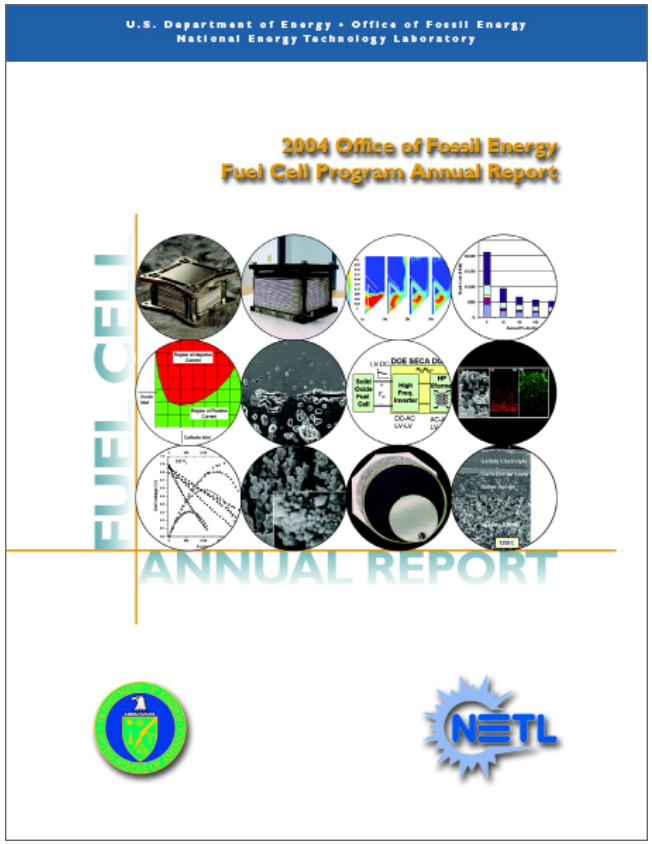
Key Industry Communication Events 2005
(Similar Scenario Expected for 2006)

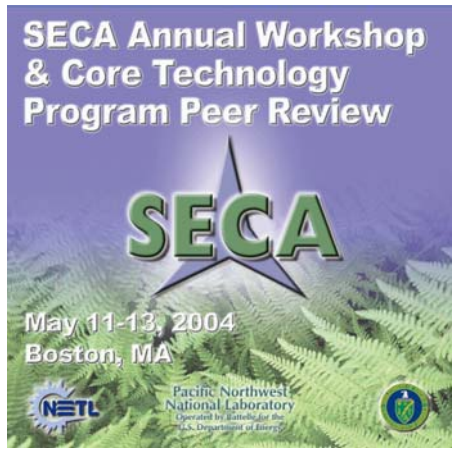
- Semi-Annual SECA CTP Peer Review, Tampa, FL, January '05
  - Peer reviews and stakeholder inputs obtained
- Annual SECA Workshop and Semi-Annual SECA CTP Peer Review, Monterey, CA, April '05
  - Industry Teams detail progress
  - Peer reviews and stakeholder inputs obtained
- Congressional Fuel Cell EXPO, May '05
- Special Topic Meeting: Diesel Reforming, June '05
- NETL Reforming, Alloys/ Metals, Materials Training, July '05
- Balance of Plant Training, August '05
- HiTEC Workshop, August '05
- Fuel Cell Seminar, Palm Springs, CA, November '05
  - World's largest fuel cell informational meetings

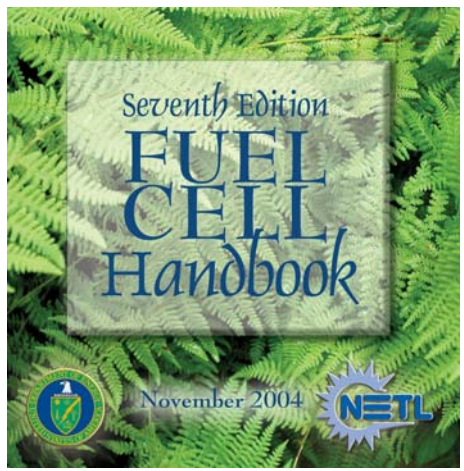


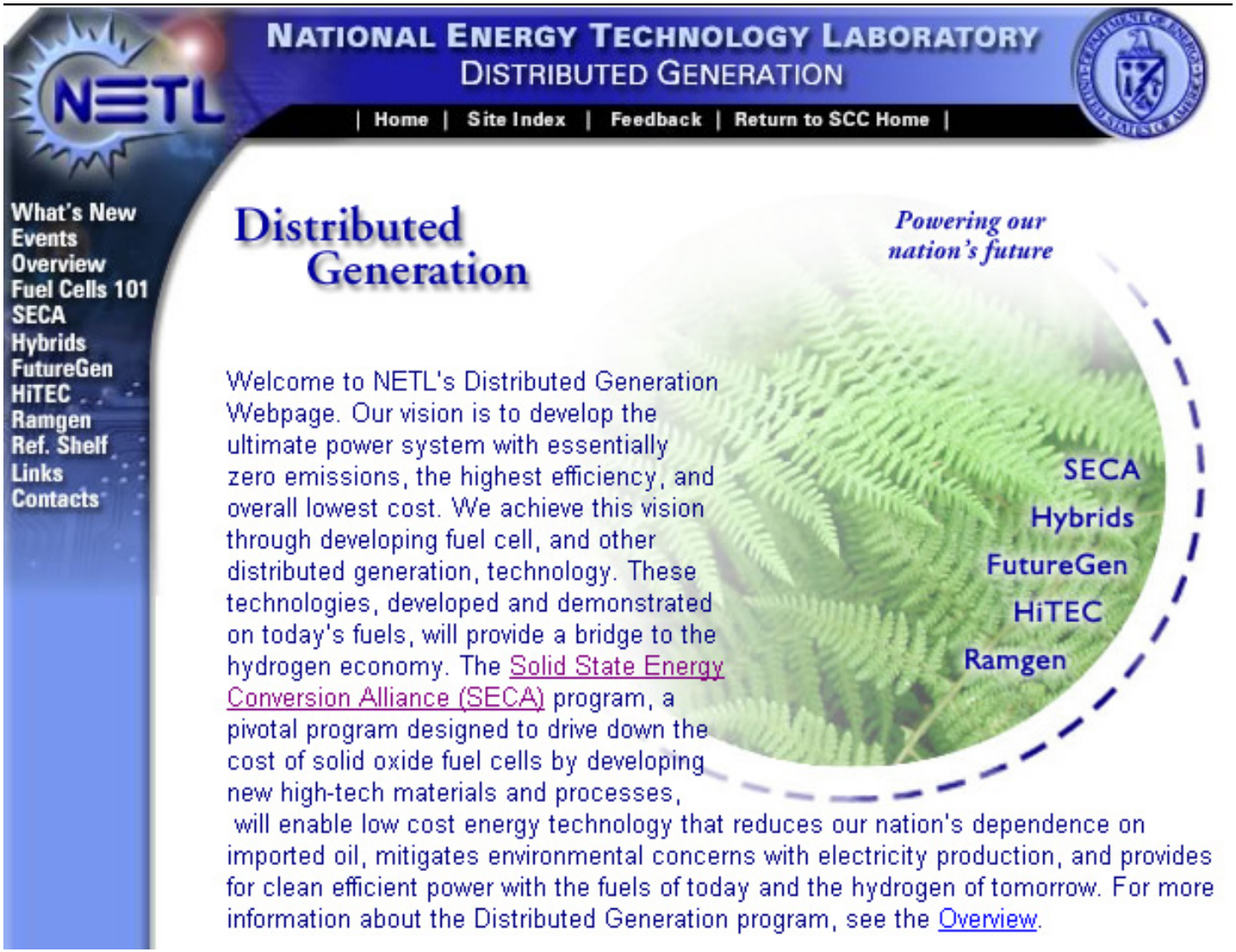
For More Information on SECA and other Projects Visit www.seca.doe.gov

- CDs can be order from website
- All projects updated in Annual Report
- Annual SECA Workshops
- Semi-Annual SECA Core Technology Peer Reviews
- Biennial Fuel Cell Handbook









http://www.netl.doe.gov/dgfuelcells

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HiTEC Solicitation

- **$1.75 million**
- **Research Topics**
  - High Temperature Electrochemical Power Generation & Energy Storage Technology
    - Energy Storage Utilizing High Temperature Electrochemical Processes
    - Revolutionary High Temperature Electrochemical Power Technology
    - Thermoelectric-SOFC Hybrid Energy Conversion
  - Advanced Fuel Feedstock
    - Effect of Coal Contaminants on Solid Oxide Fuel Cell System Performance and Service Life

SECA Fuel Cells
Solution for Today & Tomorrow

- ✓ **Fossil Fuels Today**
- ✓ **Hydrogen Tomorrow**