U. S. DOE Office of Fossil Energy
SECA Workshop and Peer Review

SECA Program Overview

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Boston, MA
May 11, 2004

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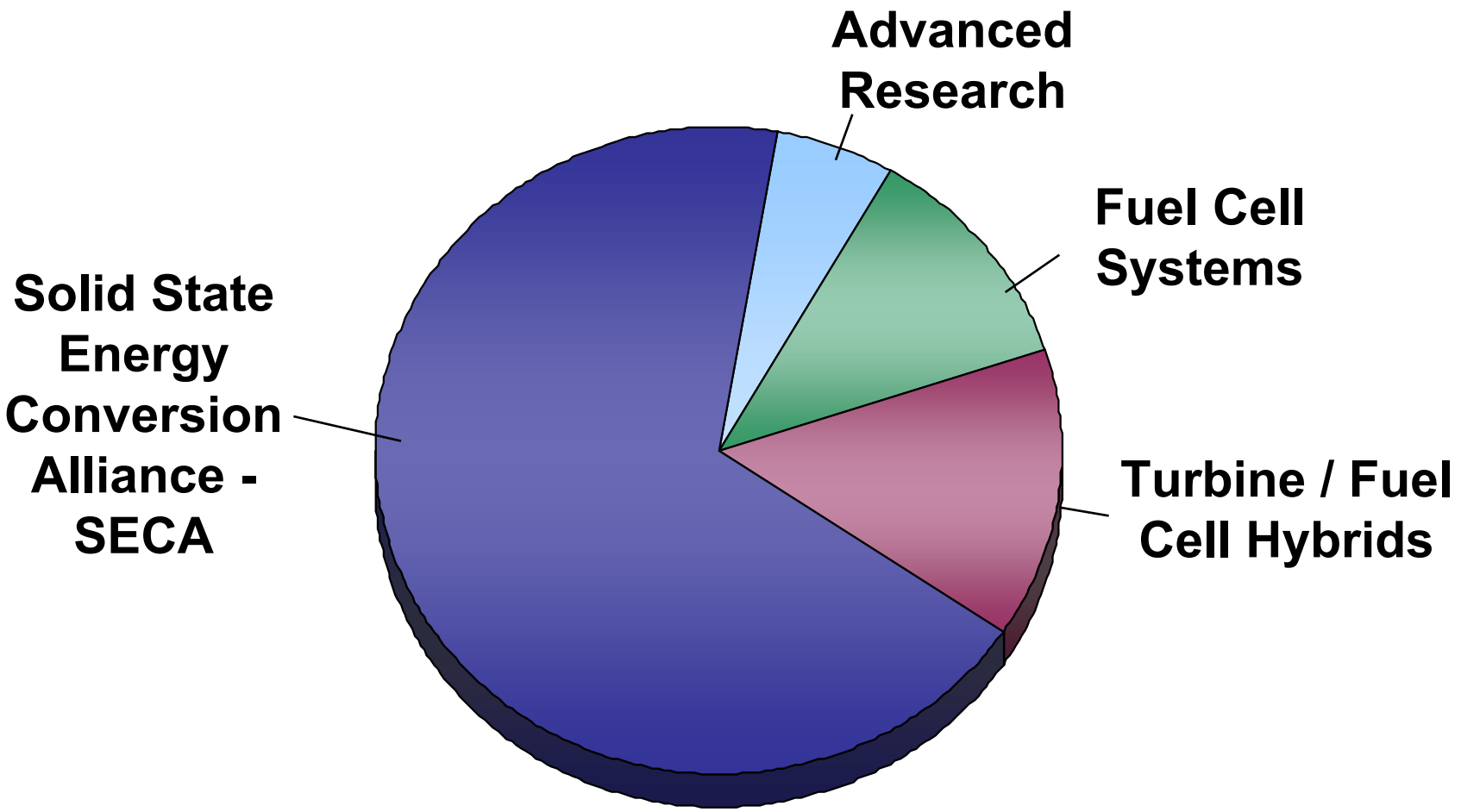
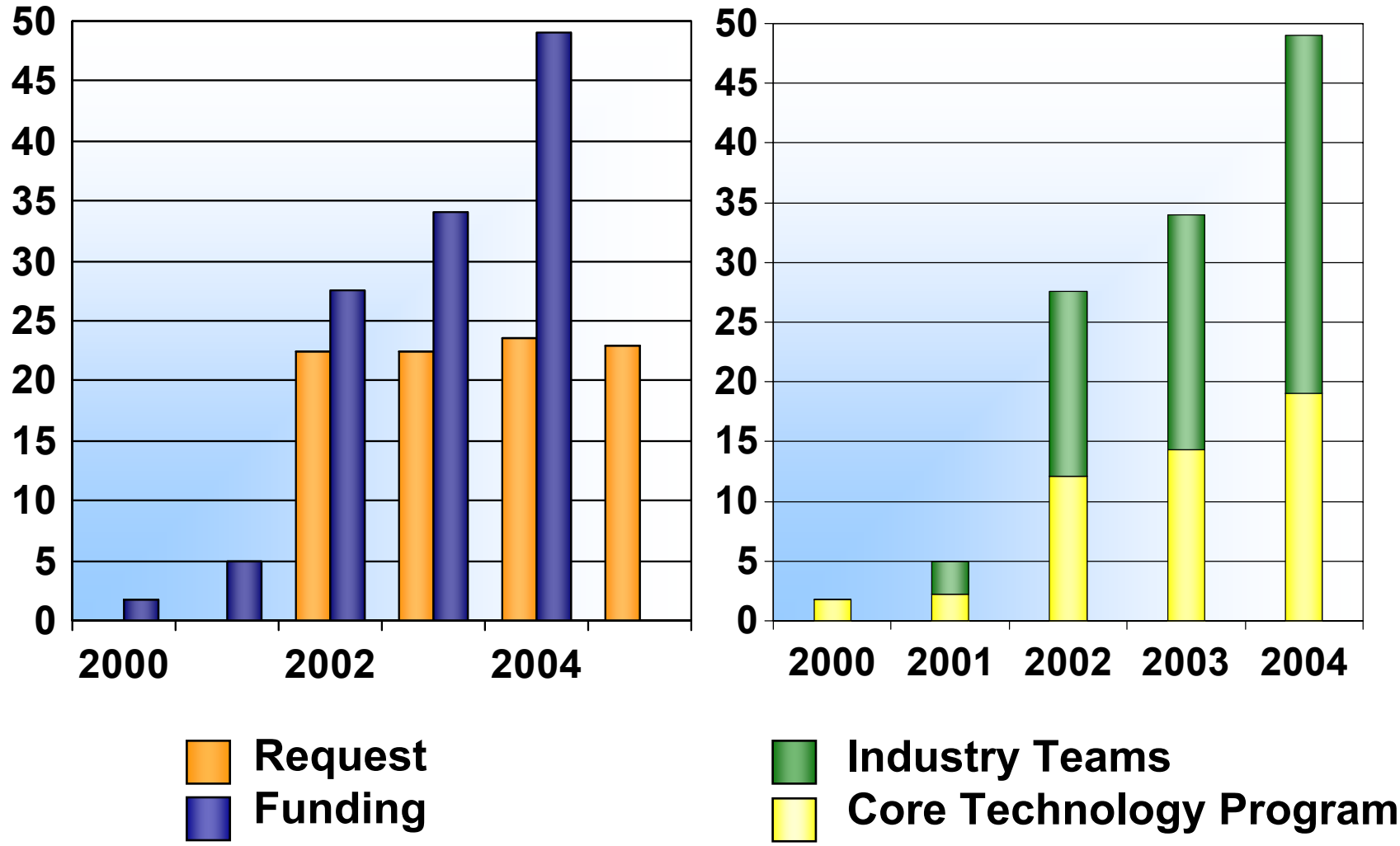
Office of Fossil Energy Fuel Cell Program

$71.7M FY 04 Funding



SECA Budget ($M)



"Always Five Years Away"

- **U. S. Government Investment in High Temperature Fuel Cell Technology**
  - **~ $1Billion over 1977 - 2002**
    - Successful Development of three Fuel Cell Systems
      - Phosphoric Acid (UTC)
      - Molten Carbonate (FCE)
      - Solid Oxide (SWPC)

- **U. S. Government Investment in Nuclear Power Technology[1]**
  ~$50Billion through 1988
  [1] Bezdek, R.H, OSTI ID 6283143

- **U. S. Government Investment in Computing Technology[2]**
  ~$9Billion; Industry $25.5 Billion from 1977 -1996
  [2]National Research Council, Funding a Revolution, Government Support for Computing Research, 1999

National Initiatives

- Clean Coal
- Global Climate Change (CO_2)
- Clear Skies (NO_x)
- Hydrogen
- Energy Security

Distributed Generation

Advanced Coal Technology/ FutureGen

Distributed Generation

Advanced Coal Technology/ FutureGen

FutureGen: A Presidential Initiative

One billion dollar, 10-year demonstration project to create world's first coal-based, zero-emission electricity and hydrogen plant

President Bush, February 27, 2003

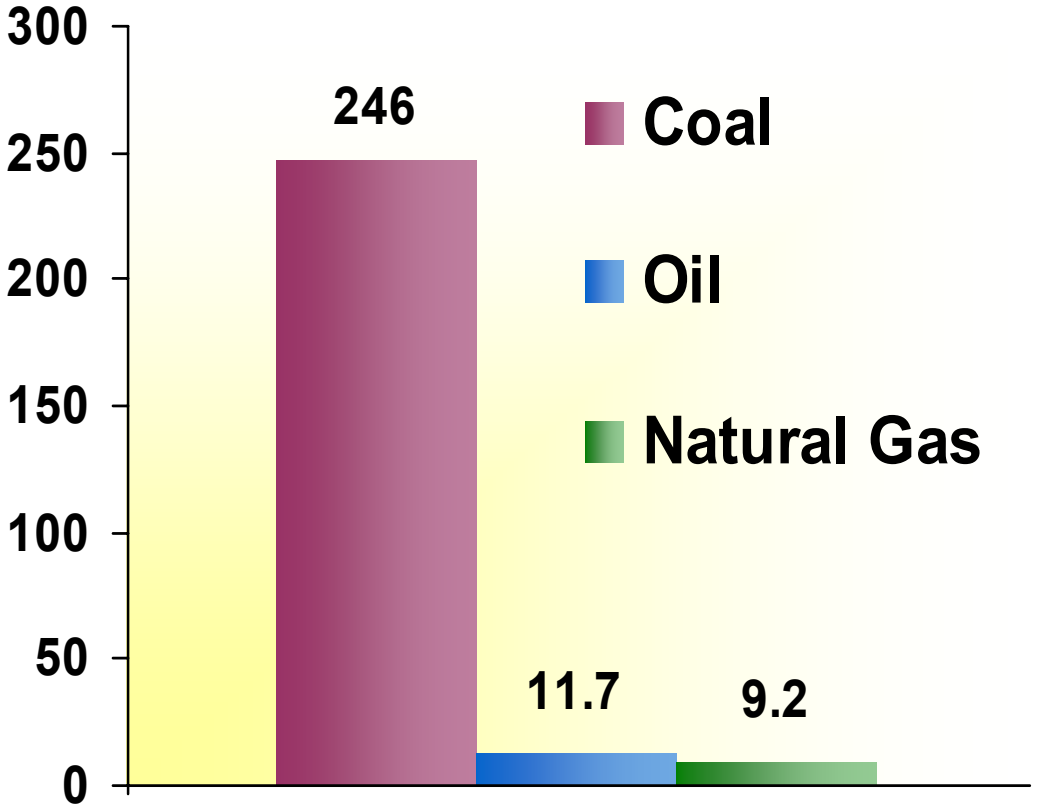
- **Produce electricity and hydrogen from coal using advanced technology**
- **Emit virtually no air pollutants**
- **Capture and permanently sequester CO_2**

Why Future Gen and Sequestration?

- **Abundant reserves**
- **Low and stable prices**
- **Technology improvements**
  - Enable near-zero emissions of air pollutants/GHGs

U.S. Fossil Fuels Reserves/Production Ratio

Shows Years Supply at Current Production



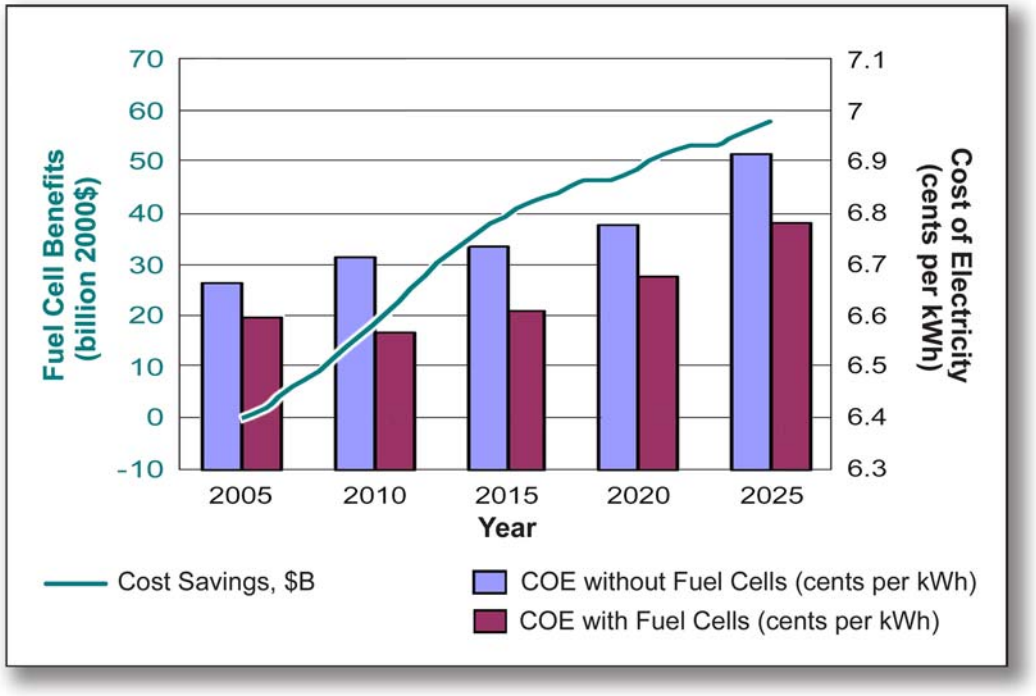
EIA- U.S. Crude Oil, Natural Gas, and Natural Gas Liquids Reserves: 2001 Annual Report, November 2002; Coal: BP Statistical Review, June 2002, World Energy Council

SECA – Path for FutureGen

- **SECA technology is an important path to achieving FutureGen cost, efficiency and emissions targets**
  - *Efficiency*
    - **27% efficiency improvement with sequestration**
    - **35% efficiency improvement without sequestration**
  - *Cost and Performance*
    - Low-cost - $400/kW SECA fuel cell an important cost-effective path to achieving 60% HHV FutureGen efficiency
  - *Environment*
    - Fuel cells and fuel cell hybrids have ultra low emissions
    - Makes isolation of CO_2 easy
- **Fuel flexibility - SECA fuel cells and FutureGen**
  - Can operate on syngas in FutureGen systems
  - FutureGen fuel cell power block can have alternate fuel capability

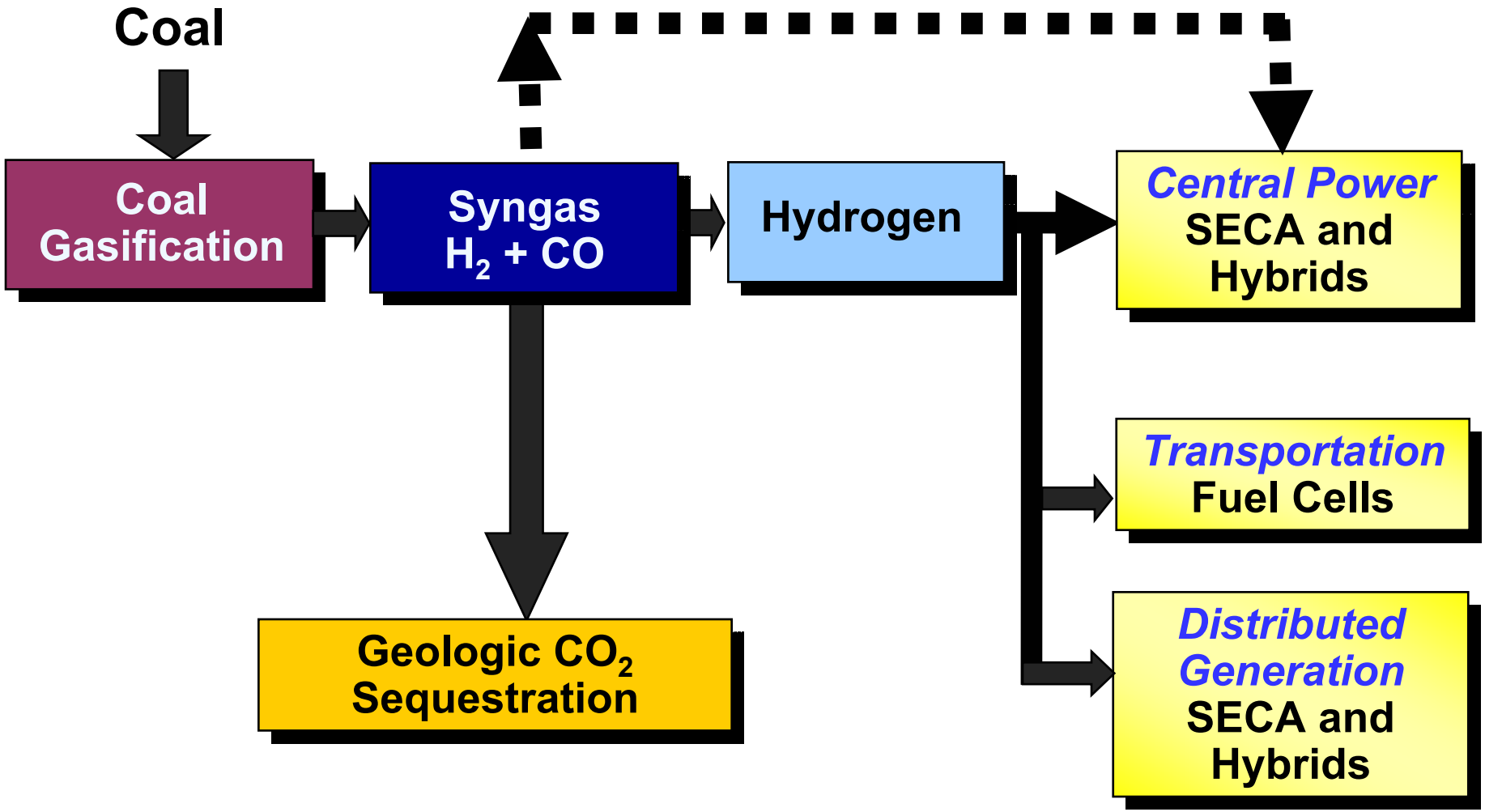
SECA Fuel Cells
Cost Savings from Market Penetration

- **$50 billion cost savings from 72 GW by 2025**
  - 54.2 GW DG, 14.1 GW Central Power, 3.4 GW Buildings



Source – EIA NEMS High Gas Price Scenario using FE Program Targets

FutureGen and SECA Fuel Cells



SECA Strategy and Central Power Generation?

- **Technology must be demonstrated and cost effective before use in large scale Central Power Generation**
  - Demonstration in large volume Distributed Generation diversifies financial risk.
  - Manufacturing and materials base established and proven.
  - Fuel cell modularity enables technology validation with minimal expense to the Government.
  - SECA materials and designs applicable to central and distributed generation; mass customization.

Fossil Energy Programs and FutureGen

SECA

SECA

Carbon Sequestration

Gasification with Cleanup & Separation

Optimized Turbines

System Integration

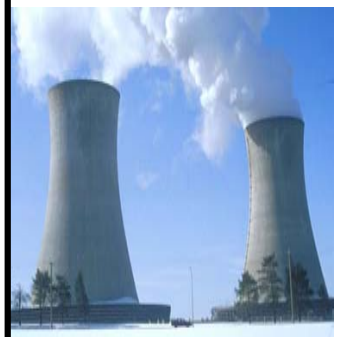
NETL

Hydrogen Economy & Fuel Cells

Hydrogen from Domestic Resources can significantly reduce our demand for oil by the year 2040

Biomass

Hydro
Wind
Solar
Geothermal



Nuclear

Oil

Coal

Natural Gas

Sequestration

HIGH EFFICIENCY & RELIABILITY

H_2

ZERO/NEAR ZERO EMISSIONS

Transportation

Distributed Generation

Source: US DOE Energy Efficiency & Renewable Energy

SECA & DG Markets - 26 GW/yr

	Range (kW)	Units per year	Size (kW)	Total (GW/yr)
Remote Generators	0.5-10	30,000	10.0	0.30
Telecommunications	2-10	30,000	10.0	0.30
Commercial	<100	165,000	50.0	8.22
Residential	2-15	1,520,000	10.0	15.20
Back-up Power	<50	80,000	6.0	0.48
SPA (appliances)	0.5	160,000	0.5	0.08
APUs	5-15	121,000	10.0	1.20
			Grand Total by 2011	25.78

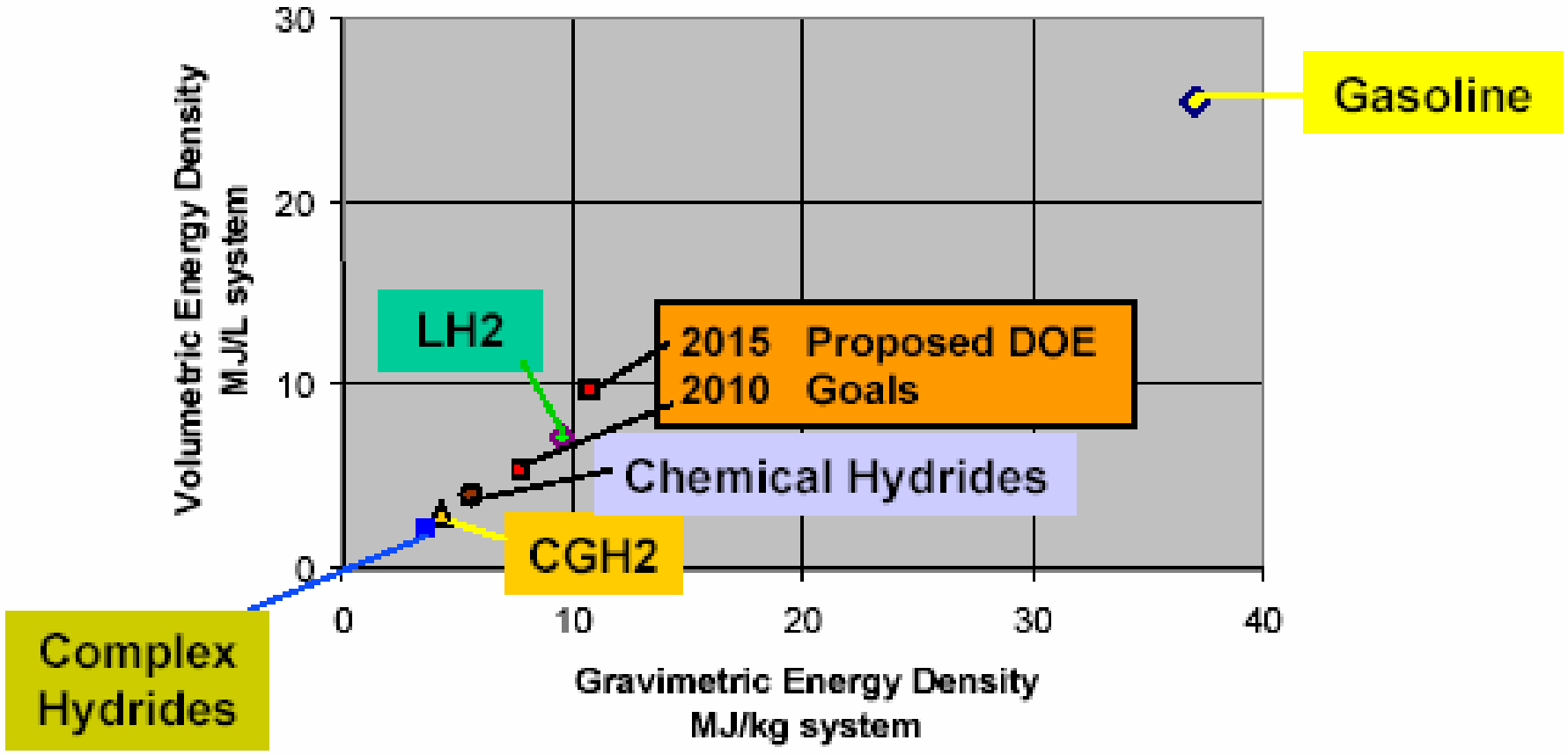
SECA Fuel Cells
Solution for Today & Tomorrow

- ✓ Fossil Fuels Today
- ✓ Hydrogen Tomorrow

DOD, NASA and SECA
Size Matters

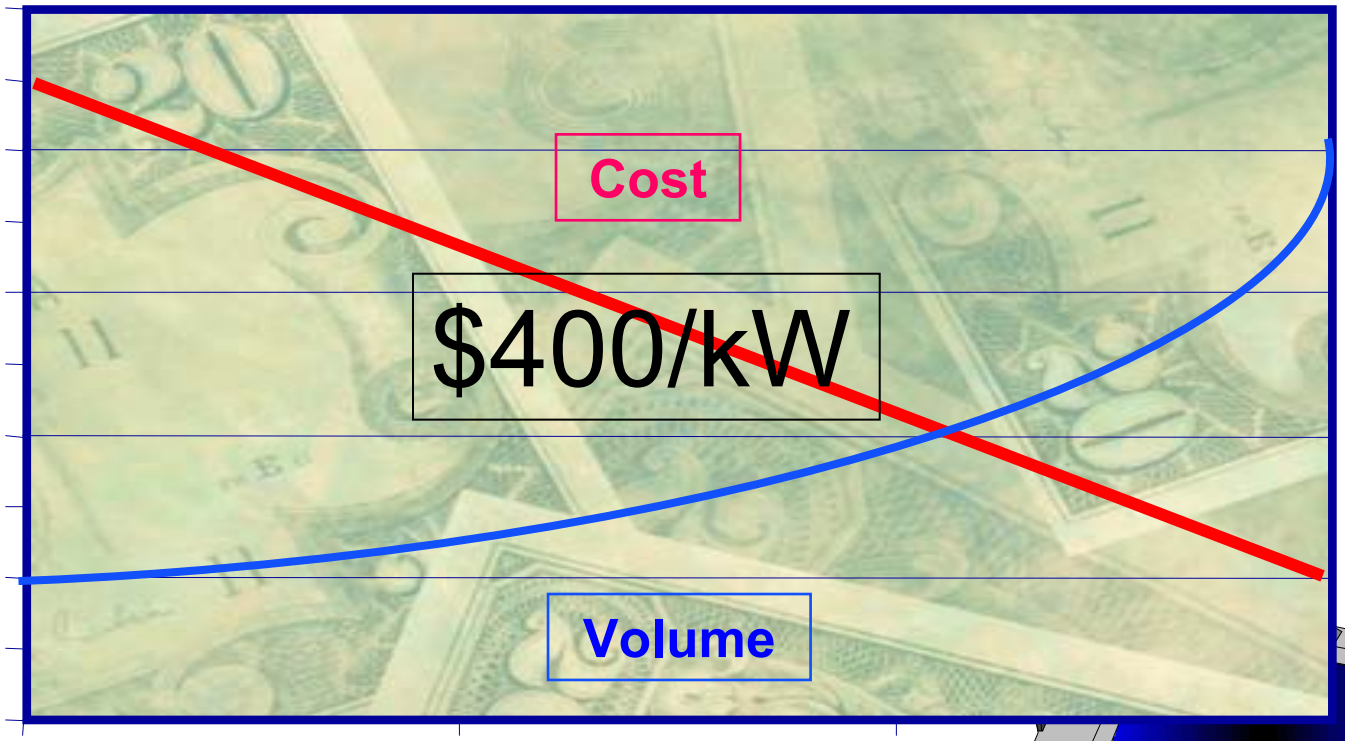
- **DOD & NASA**
  - Extend mission length
  - Quiet
  - Reduced emissions (NASA)
  - Combined functions – power, heat and water
  - ***Volume and weight***
    - Operate with High Specific Energy Fuels – Liquids
- **SECA power density targets (based on cost) minimize stack size and volume to diminishing returns.**
- **Further size and weight improvement – BOP**
- ***SECA WILL PROVIDE THE STACK TECHNOLOGY***

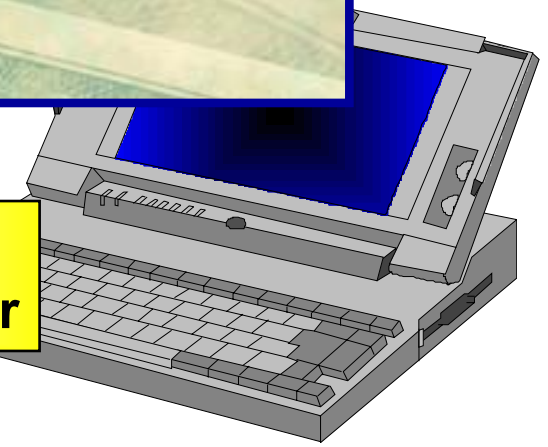
H2 Storage Systems



Source: US DOE Energy Efficiency and Renewable Energy

SECA Fuel Cells in 2010





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

SECA: Making Fuels Cells a Reality

2005

- **1st Generation Prototypes**
  - Testing & Evaluation

2010

- **$400/kW Modules**
  - Residential, Commercial, Industrial CHP
  - Transportation APUs

2012 - 2015

- **FutureGen - SECA fuel cells available**

2020

- **MW-Scale SECA fuel cells for Advanced Coal Power Plants**

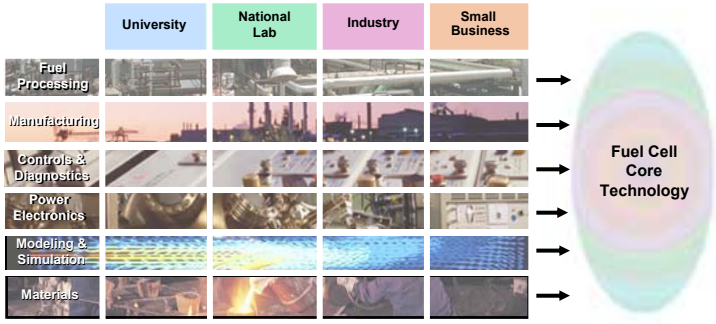
SECA Program Structure

Project Management

Needs ***Research Topics***

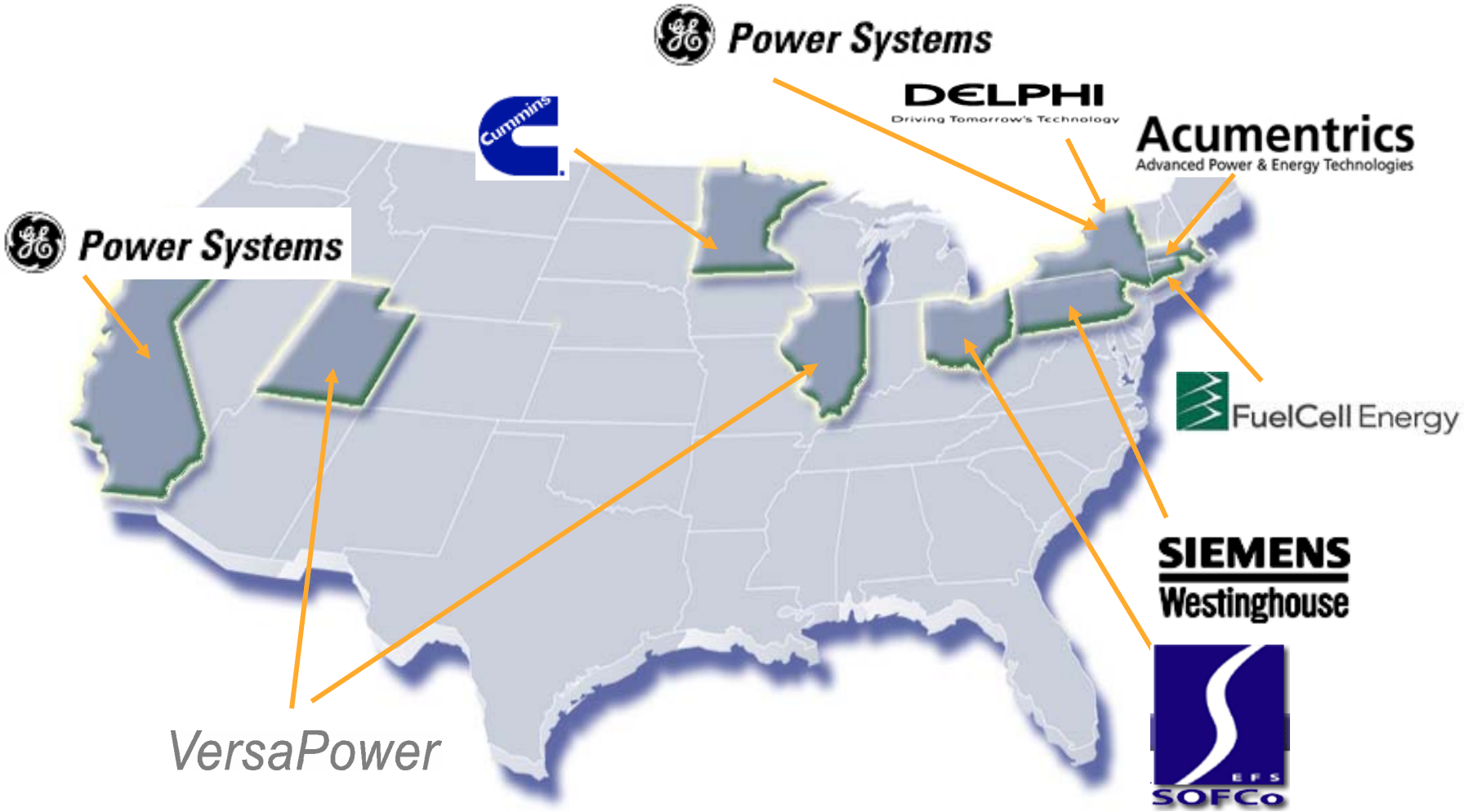
Industry Integration Teams

Technology Transfer

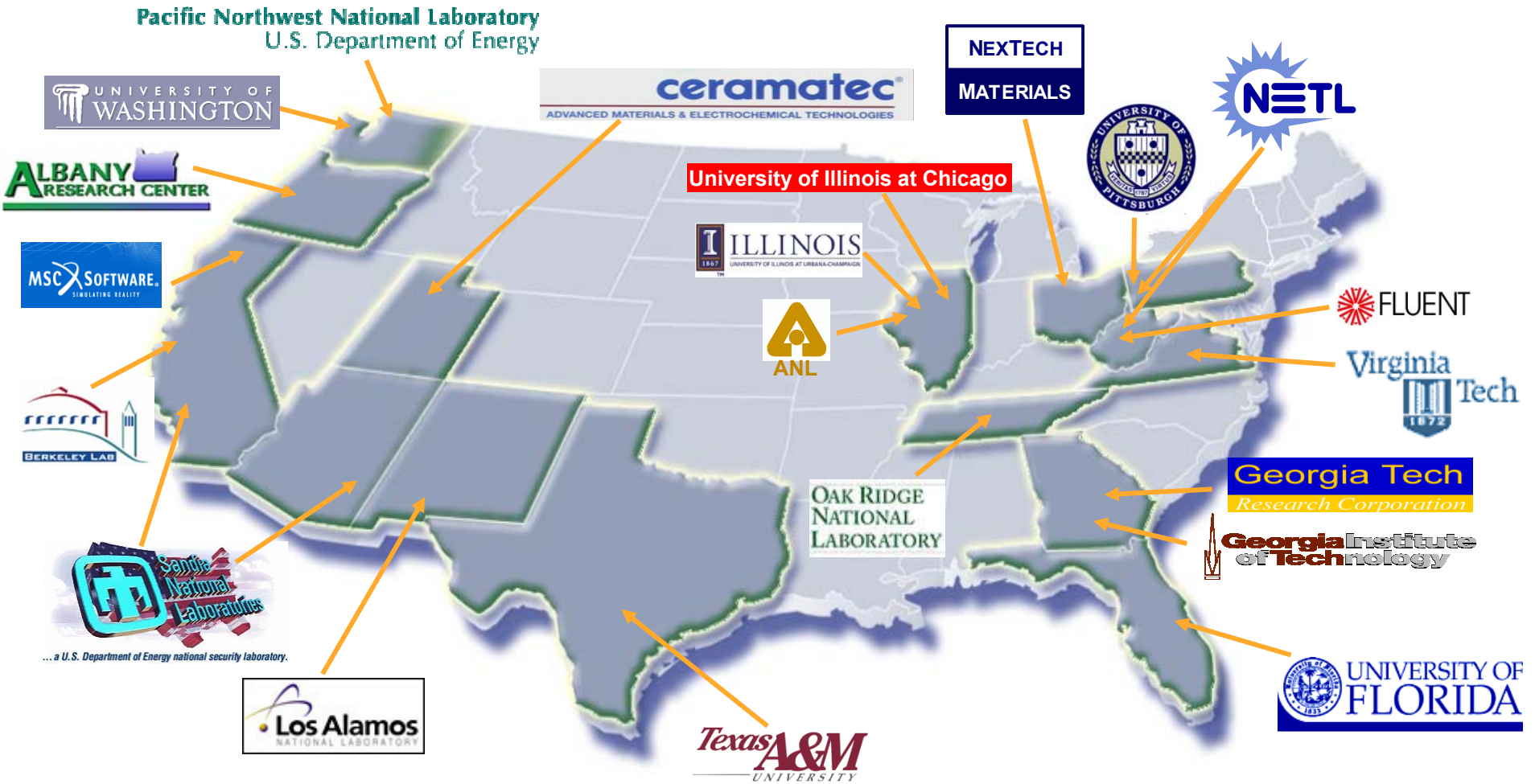


Core Technology Program

SECA Industrial Partners



SECA Core Technology Partners



NETL

Intellectual Property
Cornerstone of the Alliance

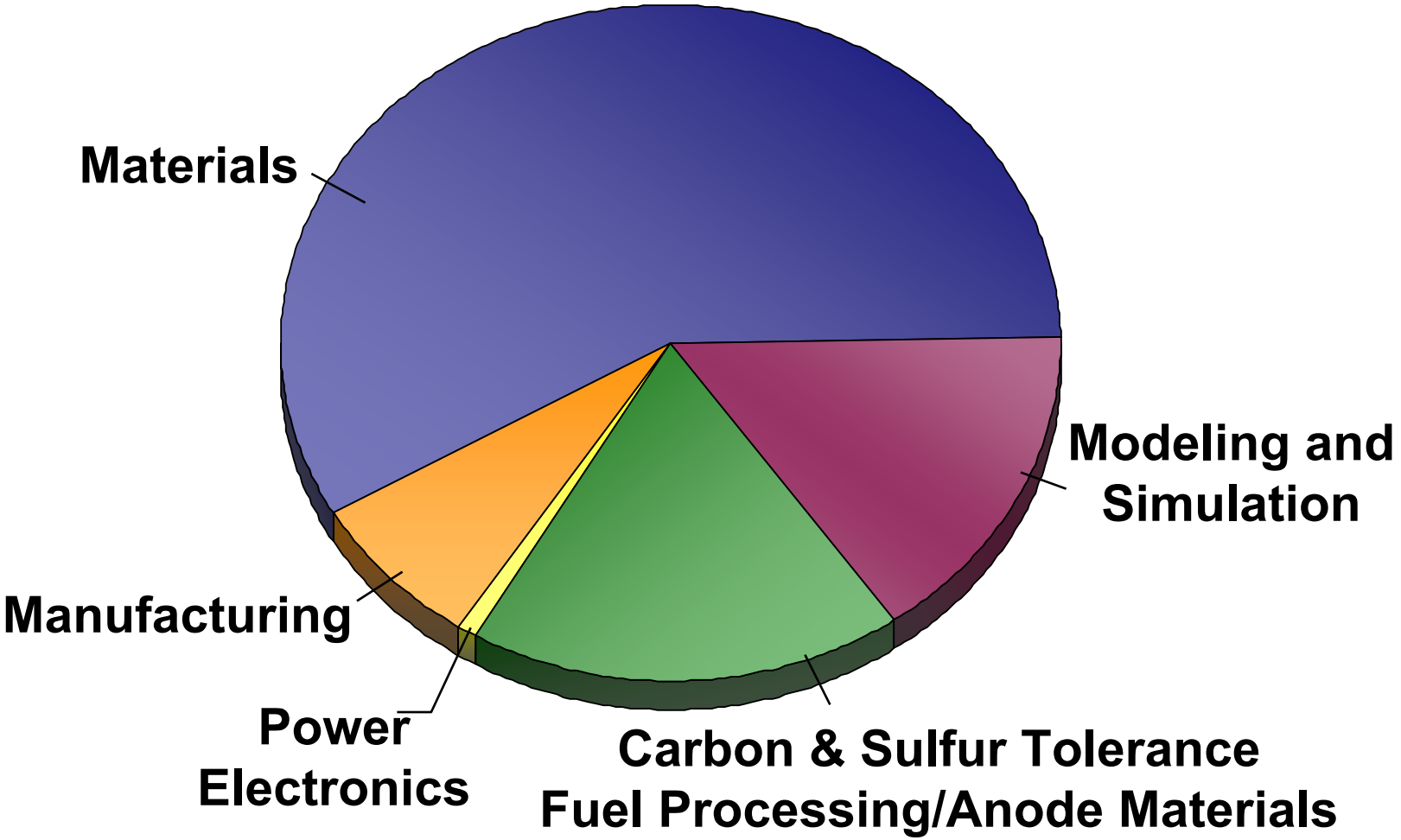
- **Non-Exclusive License** — **CTP ➡ Industry Teams**
  - **Ready market of potential licensees**
  - **Best designs vs. highest bidder**
- **Promotes Collaboration - Limits Redundancy**

Priorities: *Core Technology Program*

1	Gas seals	• Rigid and compressive seals
1	Interconnect	• Modifying components in alloys • Coatings
1	Failure Analysis	• Models with electrochemistry • Structural failure criteria
2	High Temperature Heat Exchanger	• Identification and/or development of materials
2	Cathode performance	• Micro structure optimization • Mixed conduction • Interface modification
2	Fuel Processing/ Anode	• Metal oxides with interface modification • Catalyst surface modification • Characterize thermodynamics/kinetics
3	Material cost	• Lower cost precursor processing

SECA Core Technology Program

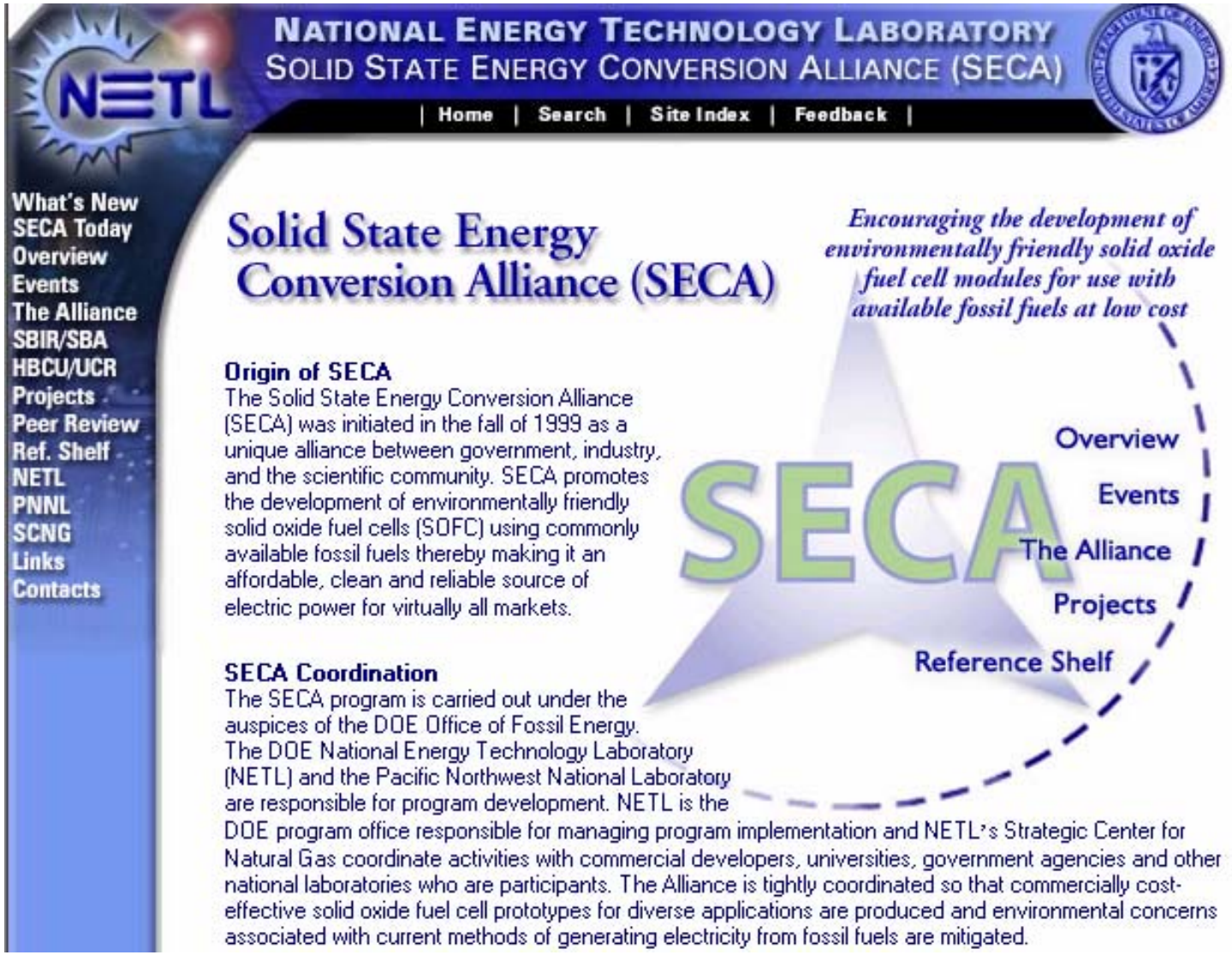
$19M FY 04 Funding



Near Term Activities

- **Core Technology Program Solicitation**
  - Selections announced in June
    - Seals
    - Interconnects
    - Carbon and Sulfur Tolerance
      - Diesel Reforming
- **Workshops (Summer 04)**
  - Interconnects
  - Computational Chemistry
- **MARC, FLUENT, STAR-CD Training (Summer 04)**

  @Pacific Northwest National Laboratory



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SOLICITATIONS

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