

# New Horizons in Natural Gas Technology



*Natural Gas Technologies II  
Ingenuity & Innovation*

*February 8 – 11, 2004*

*Rita A. Bajura, Director*

**National Energy Technology Laboratory**

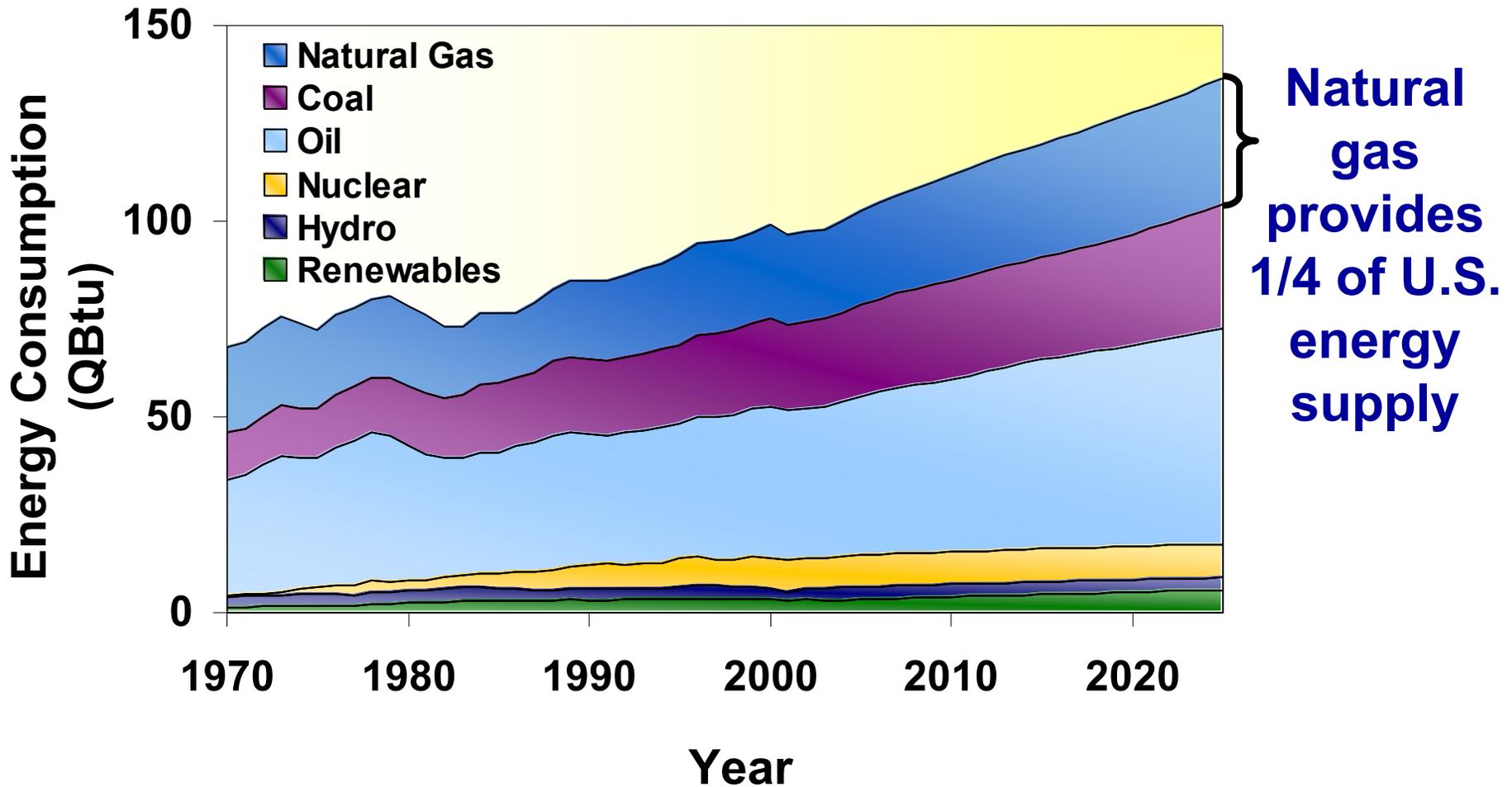


**Office of Fossil Energy**



# U.S. Energy Consumption

## *Energy Consumption by Fuel, 1970 – 2025*



# DOE Mission

## *Overarching Mission*

- Advance U.S. national, economic and energy security

## *Energy Strategic Goal*

- Promote a diverse supply and delivery of reliable, affordable, and environmentally sound energy



Photo: PNNL

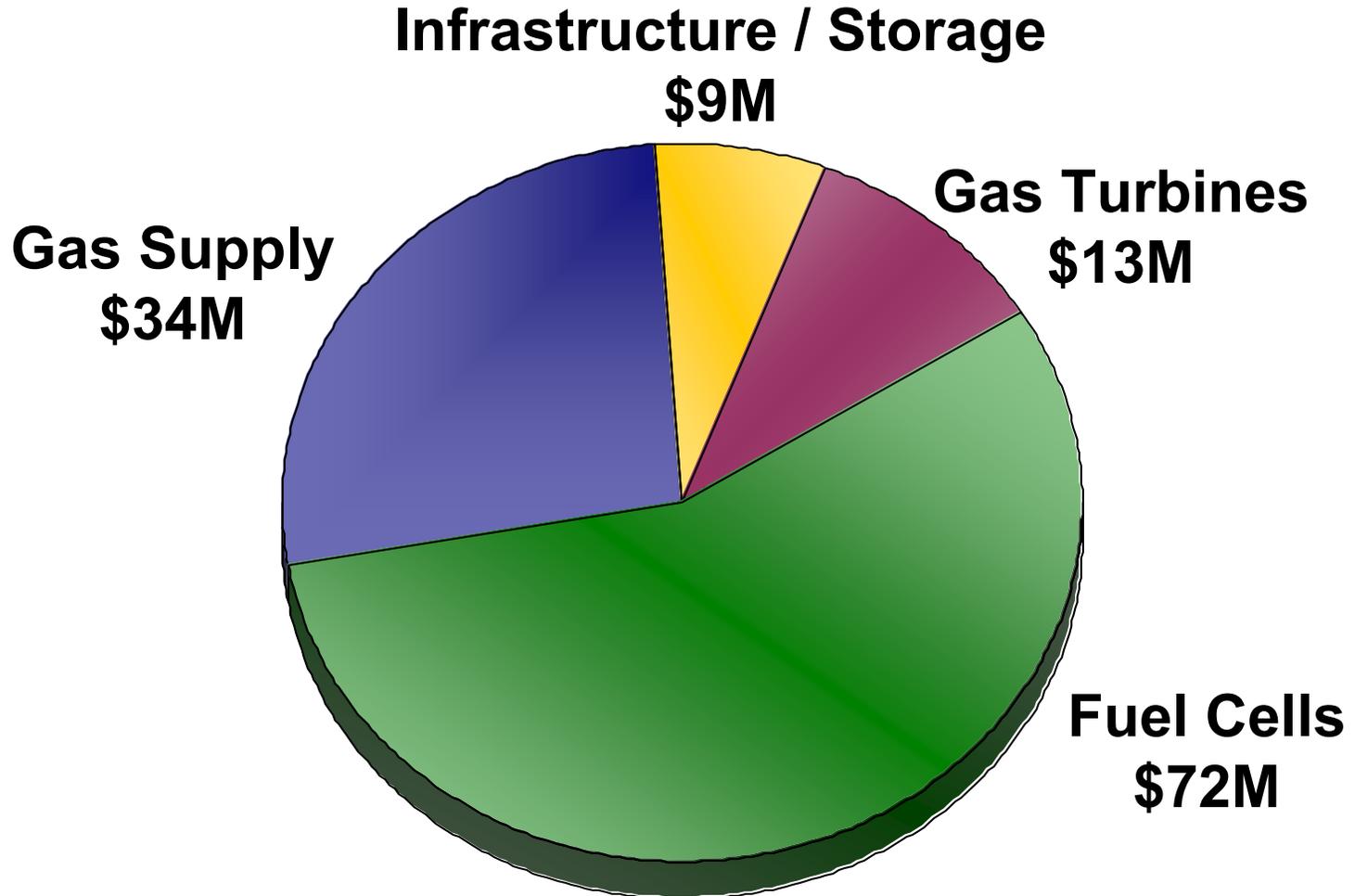
# Policy Tools

- Tax codes
- Price supports
- Portfolio standards / mandates
- Direct purchases
- Subsidies
- Consumer education
- Financing
- R&D funding



# DOE / FE's FY 2004 Natural Gas R&D Budget

*\$128 Million*



# Gas Supply



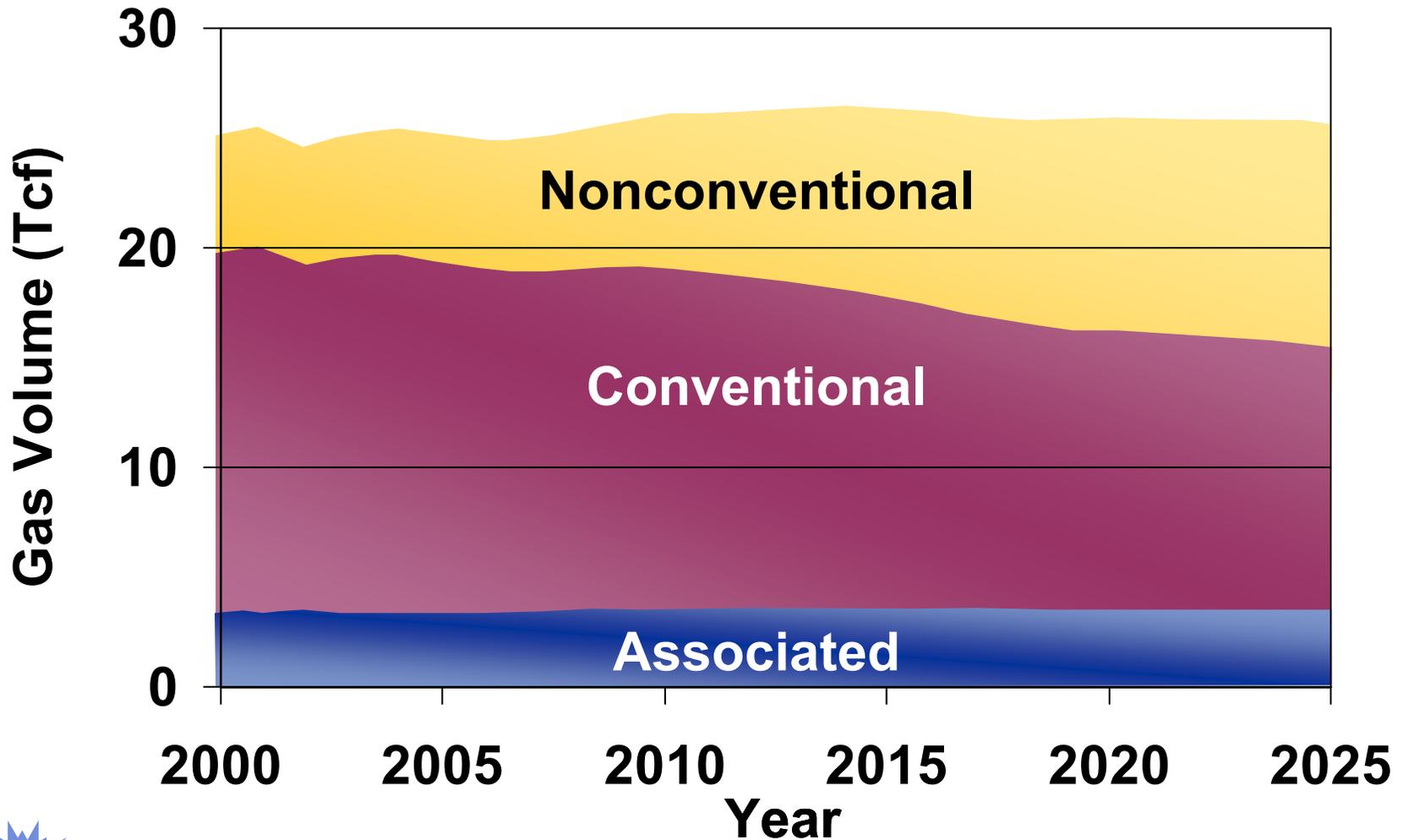
# Gas Supply

**Develop technologies to help affordably produce domestic natural gas with minimal environmental impact**

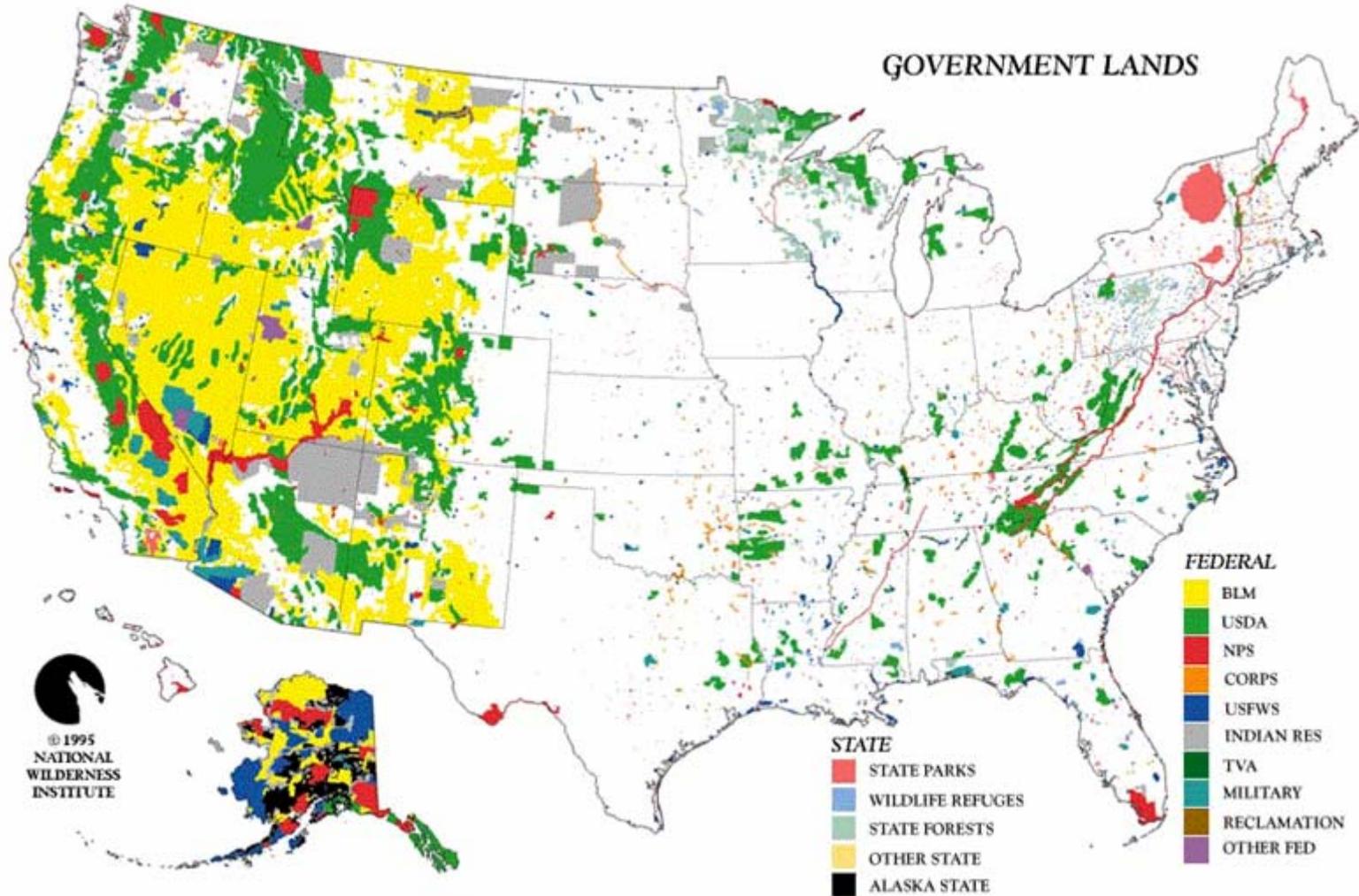
**Help Meet 40% Increase in Gas Demand by 2025**



# U.S. Lower-48 and Non-Arctic Canadian Gas Production



# Government Lands Often “Environmentally Sensitive”

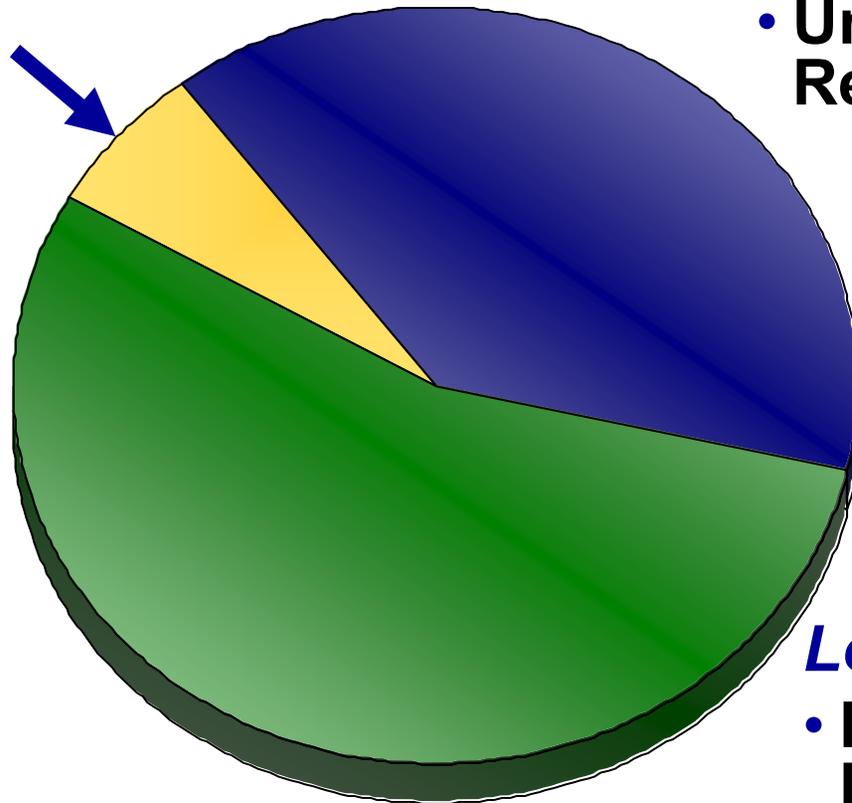


# FY 2004 Gas Supply R&D Portfolio

*>100 Projects - \$34M in FY 04 Funding*

## **Near-term**

- Existing Fields



## **Mid-term**

- Unconventional Resources

## **Long-term**

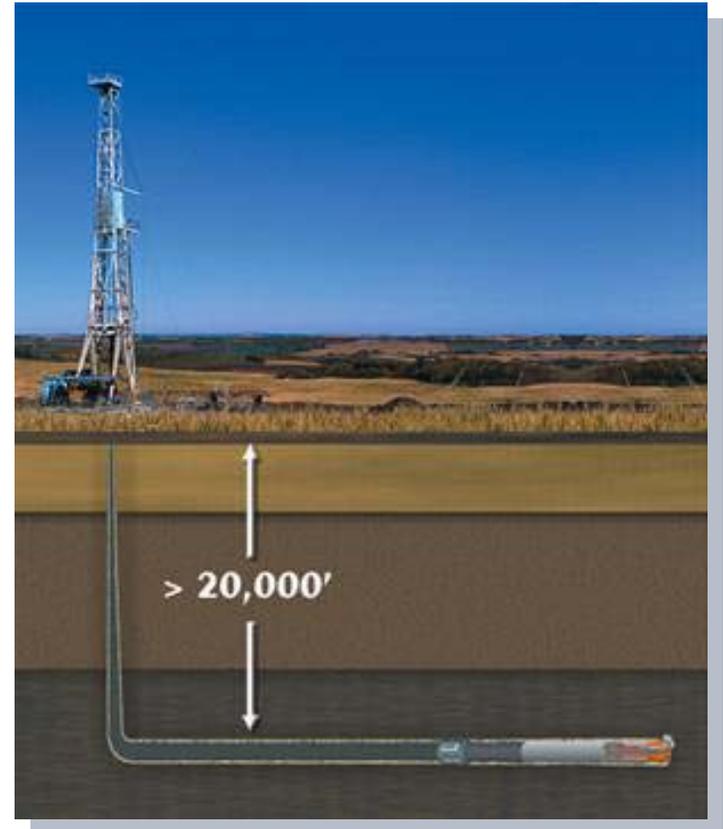
- Future Resources



# Deep Trek Program

## *Technologies to Tap Gas at > 20,000 Feet*

- **Resource**
  - High temp and pressure
  - Highly corrosive environment
- **R&D areas**
  - High-speed wellbore data transmission
  - High-performance DCS systems
  - High-temp & high-pressure sensors
  - Wear-resistant coatings & materials



# Mallik Gas Hydrate Project

- **First dedicated hydrates test wells**
  - Demonstrated that warm brine can produce significant gas flow
- **Mackenzie Delta, Canada**
- **International team**



*Well photo by Hideaki Takahashi, Japex Canada Ltd., courtesy of Natural Resources Canada*

# Coupled Coalbed Methane Production / Carbon Sequestration

- **Demonstrate:**
  - CO<sub>2</sub>-enhanced coalbed methane production
  - Permanence of CO<sub>2</sub> sequestration
- **West Virginia**
- **Consol**

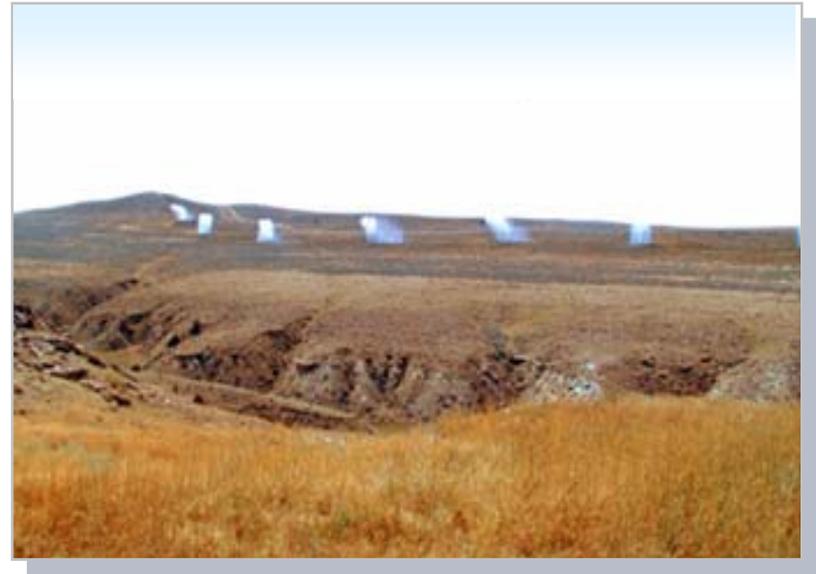


*Field Testing Site*

# Gas Environmental Program

## *Solutions for Environmental Barriers Limiting Domestic Production*

- **Federal lands access**
  - Reduce permitting times
  - Science-based analysis
- **Coal bed methane / water issues**
  - Treatment technologies
  - Educational materials



# Infrastructure / Storage



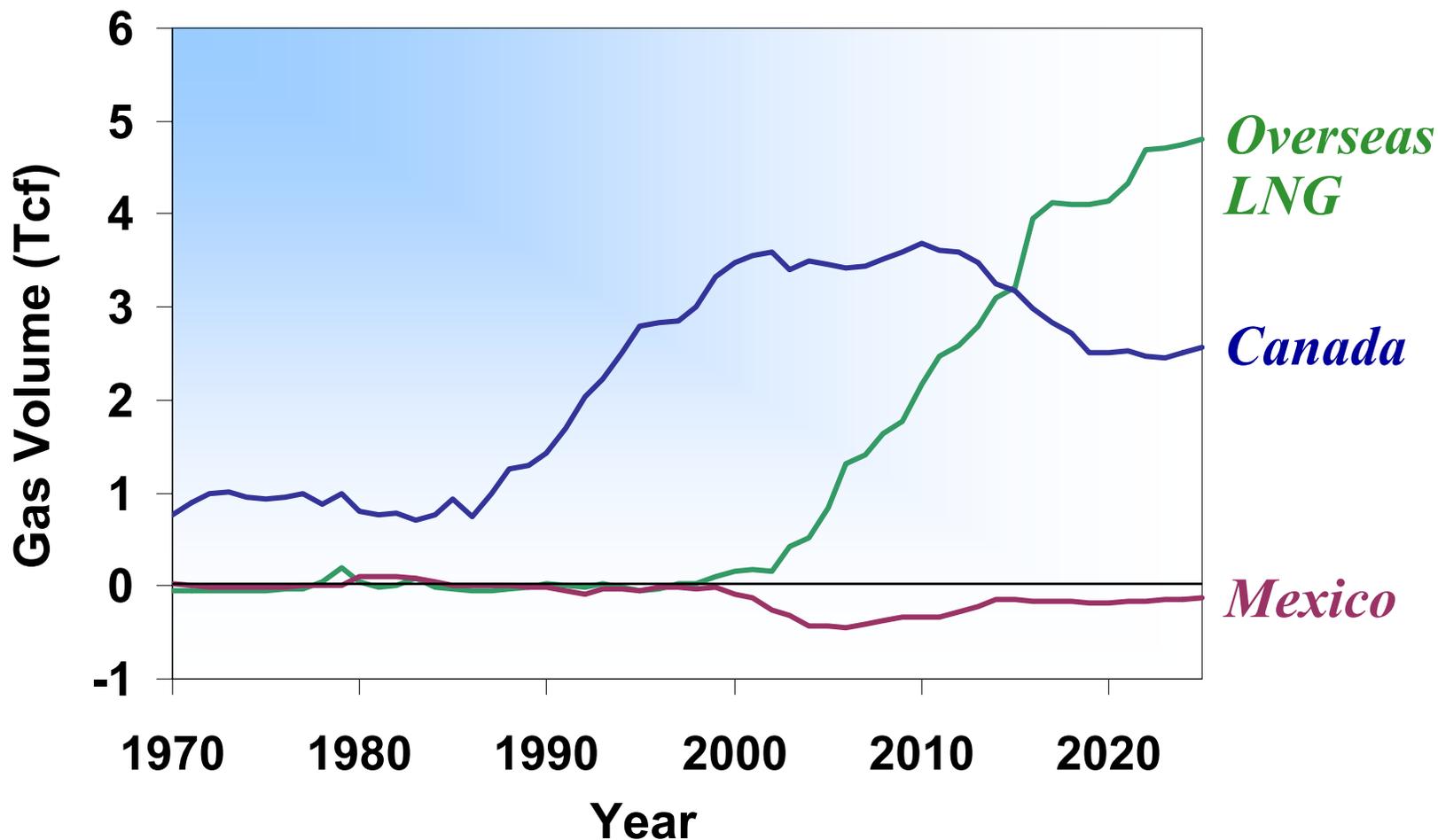
# Infrastructure / Storage

- Aging infrastructure
- Heightened security concerns
- Deliverability from gas storage fields difficult to maintain
- Growing LNG imports



# Increasing Reliance on Imported LNG

## *Net U.S. Imports of Natural Gas, 1970 – 2025*



# Infrastructure / Storage Program Goals

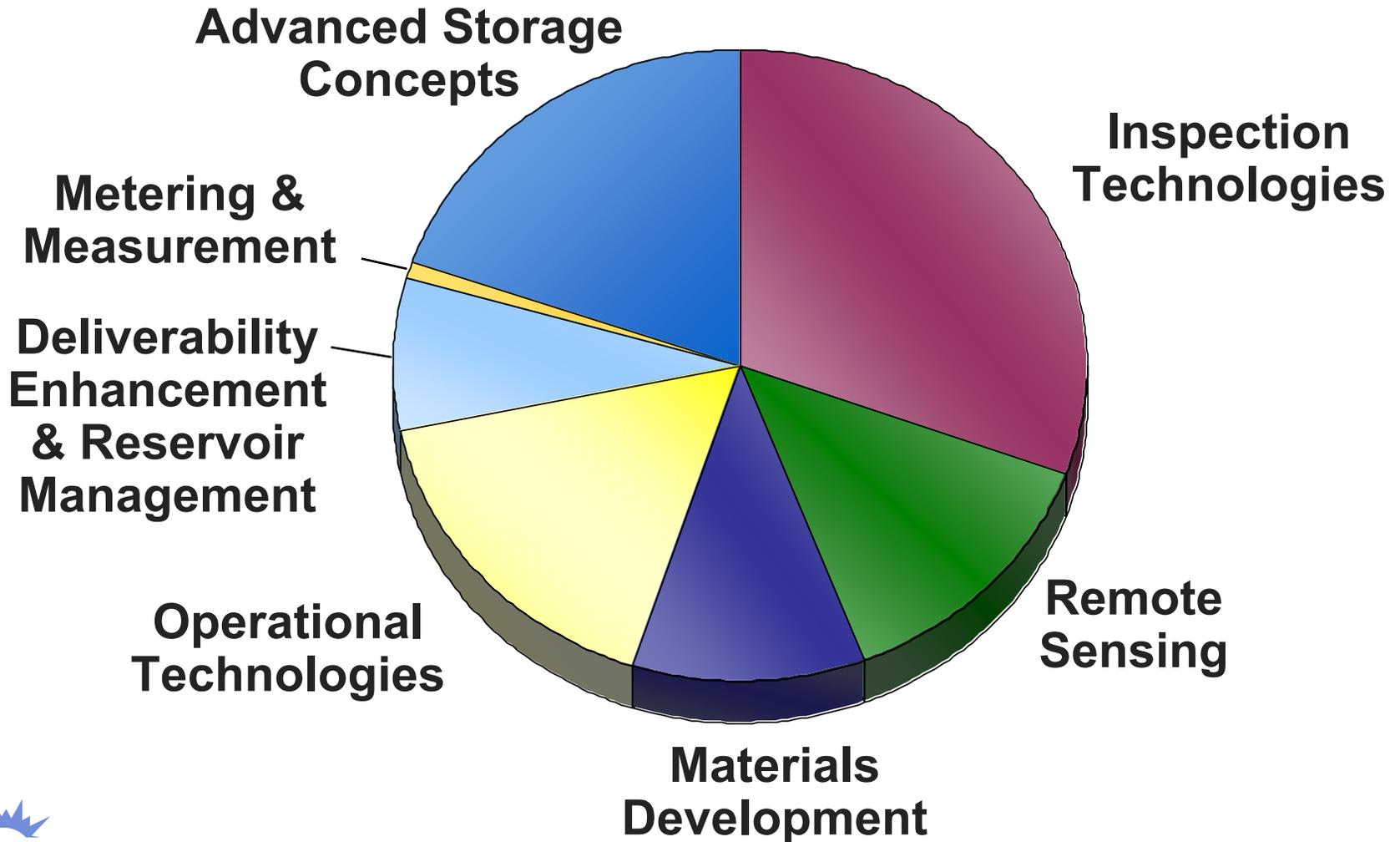
*Develop technologies that will —*

- **Maintain / enhance system reliability and integrity**
- **Increase gas deliverability**
- **Reduce environmental impact**
- **Support infrastructure security**



# Infrastructure / Storage R&D Portfolio

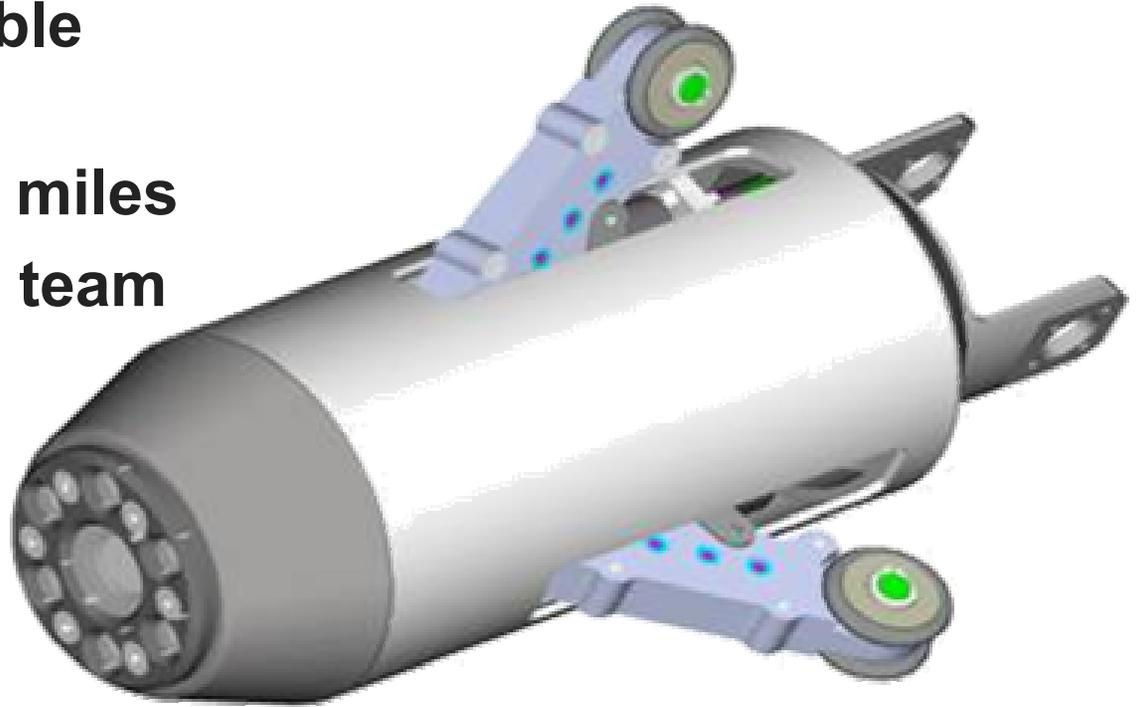
*60 Projects - \$9M FY 04 Funding*



# Northeast Gas Association

## *Long-Range, Untethered Inspection Robot*

- Use in 6- to 8-inch pipelines
- Two cameras
- Highly maneuverable
- Current platform communicates 1-2 miles
- CMU with industry team



*The “Explorer”*

# Edison Welding Institute

- Internal pipeline repair methods
- Could reduce repair costs by 50%
- Other team members
  - PG&E
  - PRCI



# Liquefied Natural Gas

## *Facilitate Anticipated Ramp-up in LNG Imports*

- **Safety studies**
- **Stakeholder education**
- **Interagency collaboration to speed permitting**
- **Ministerial conference - 12/03**
- **R&D**

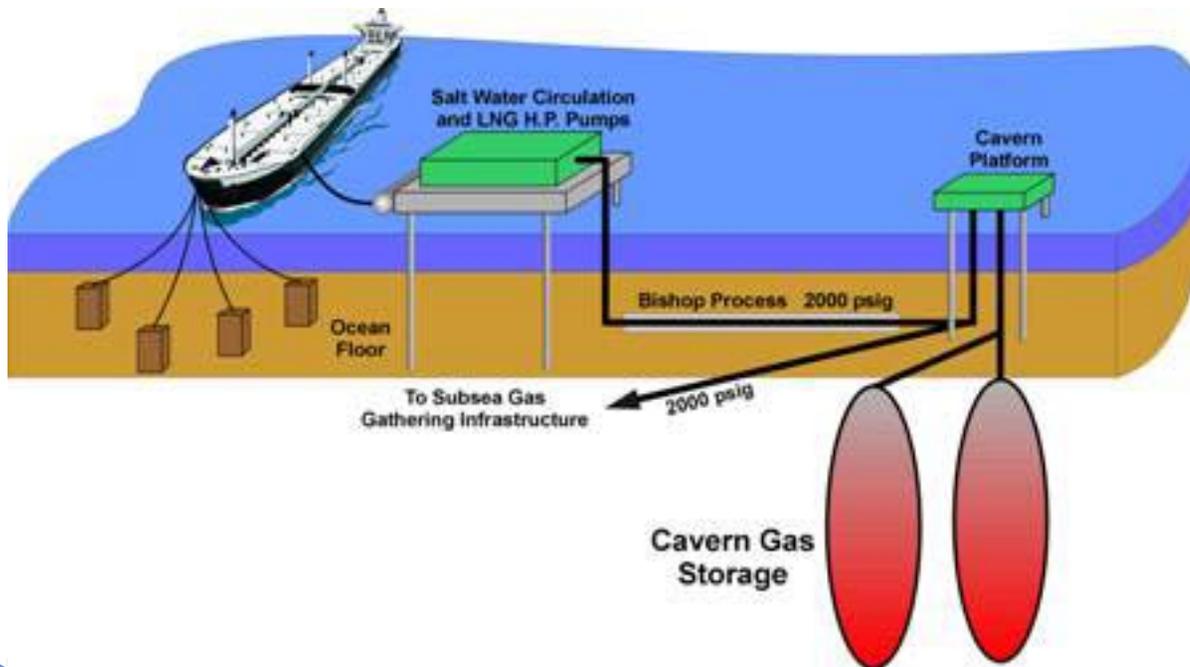
*Dominion's Cove Point Facility*  
*Source: [www.dom.com](http://www.dom.com)*



# Bishop Process

## *LNG Storage in Salt Caverns*

- Enables offshore unloading of LNG
- Pressurize LNG to 2,000+ psi and warm to 40 °F
- Store gas in salt caverns



- Less costly
- More flexibility
- Greater security

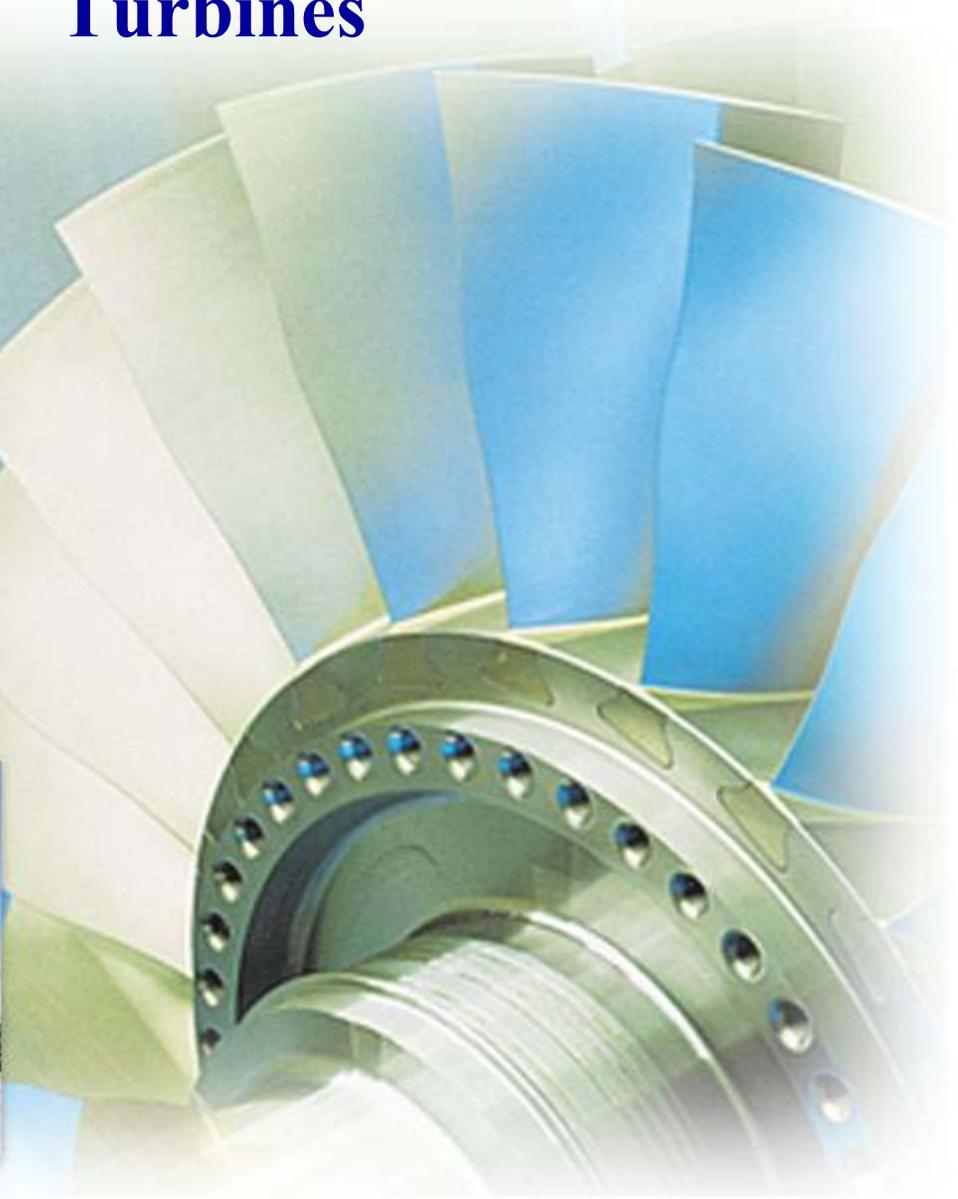
# Roadmapping Activities

## *Infrastructure / Storage*

- ✓ **Natural Gas Infrastructure Roadmap Update - 2/8/04**
- **LNG Technology Roadmap – Spring 2004**



# Turbines



# Turbine Program

- **Develop advanced combustion turbines for advanced coal-gasification power systems**
  - Most improvements apply to natural gas-fueled turbines



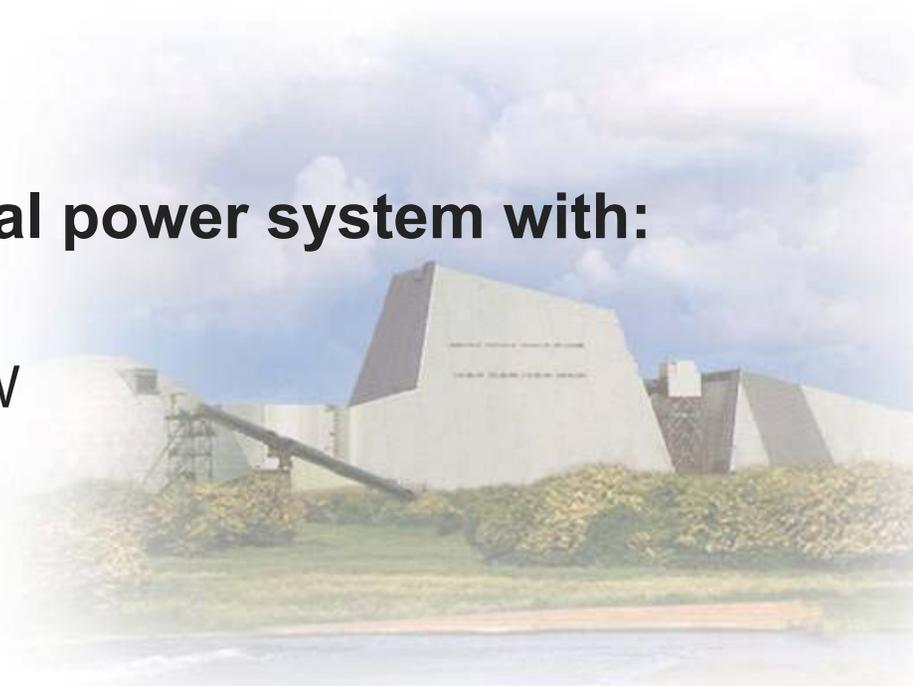
# Turbine Program Goals

## *Syngas Turbines - 2010*

- **Commercial design for coal power system with:**
  - 45 – 50% (HHV) efficiency
  - Capital cost < \$1,000 / kW
  - Near-zero emissions

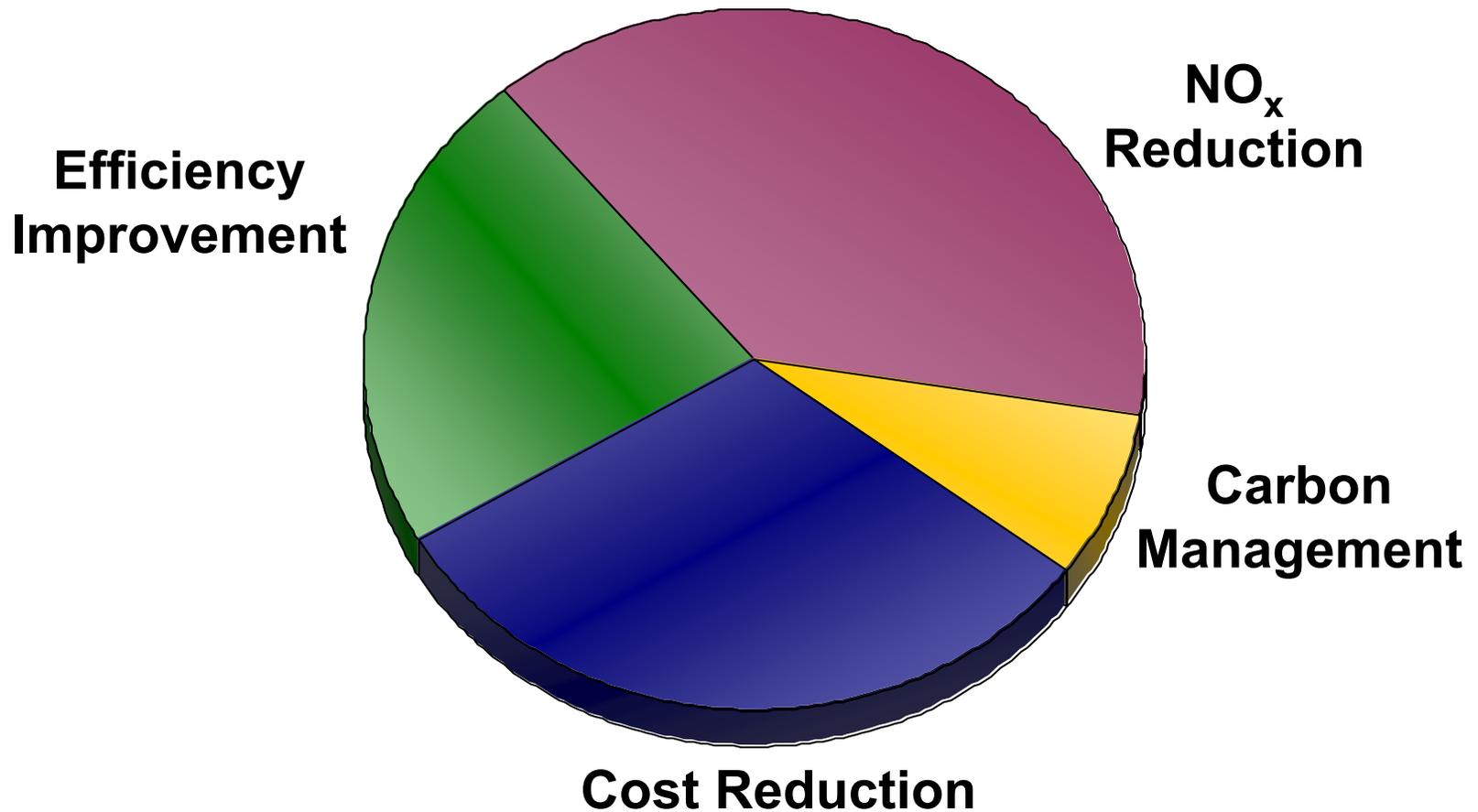
## *Hydrogen Turbines - 2020*

- **Commercial design for coal power system with:**
  - 60% efficiency
  - Capital cost \$800 – 900 / kW
  - Near-zero emissions
  - Zero CO<sub>2</sub> option



# Turbines R&D Portfolio

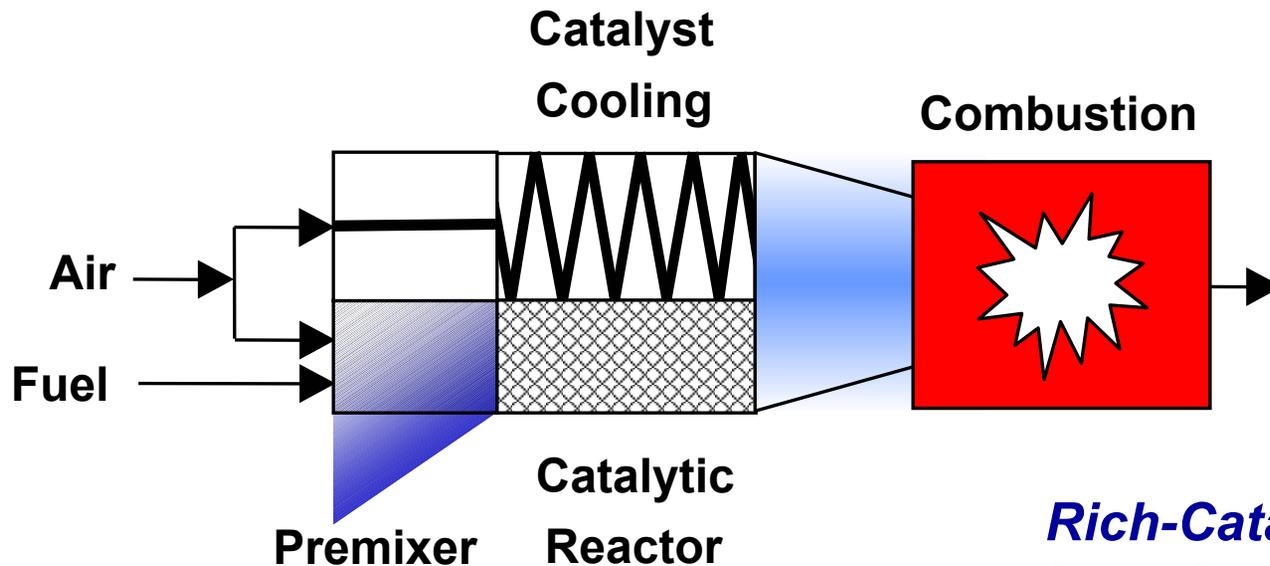
*19 Projects - \$13M FY 04 Funding*



# Low Emissions Syngas Combustion System

## *Precision Combustion*

- **Burn both syngas and natural gas**
  - < 3 ppm NO<sub>x</sub> at flame temperatures up to 2,700 °F
  - > 500 °F operating range with low NO<sub>x</sub> and CO

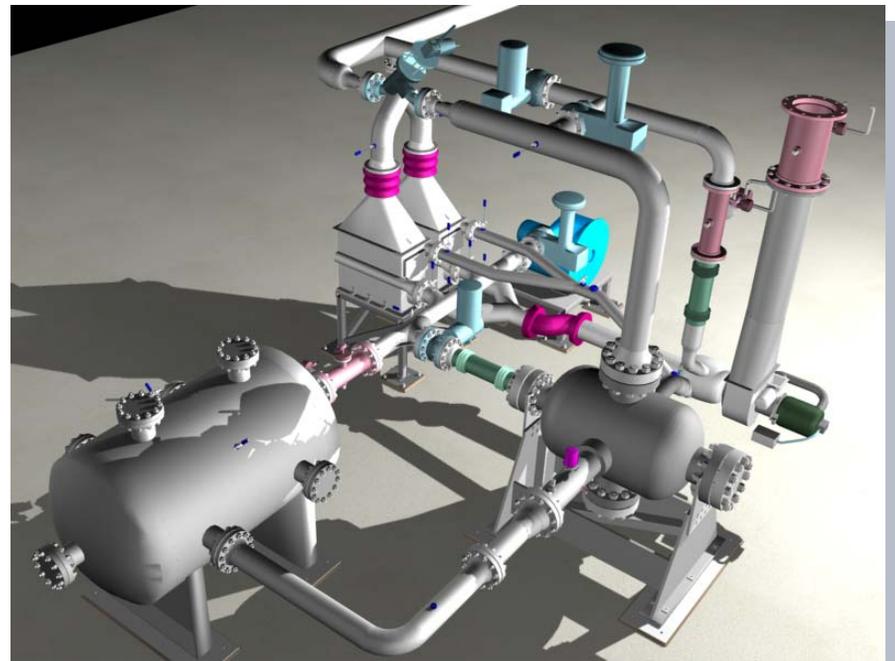


***Rich-Catalytic /  
Lean-Burn System***

# Dynamic Control Studies

## *Turbine / Fuel Cell Hybrids*

- **Hardware and software to assess dynamic control and performance issues**
  - Thermal and load transients
- **NETL**



# Stationary Fuel Cells



# Fuel Cell Program

**2010**

- Natural gas fueled systems for distributed generation

**2020**

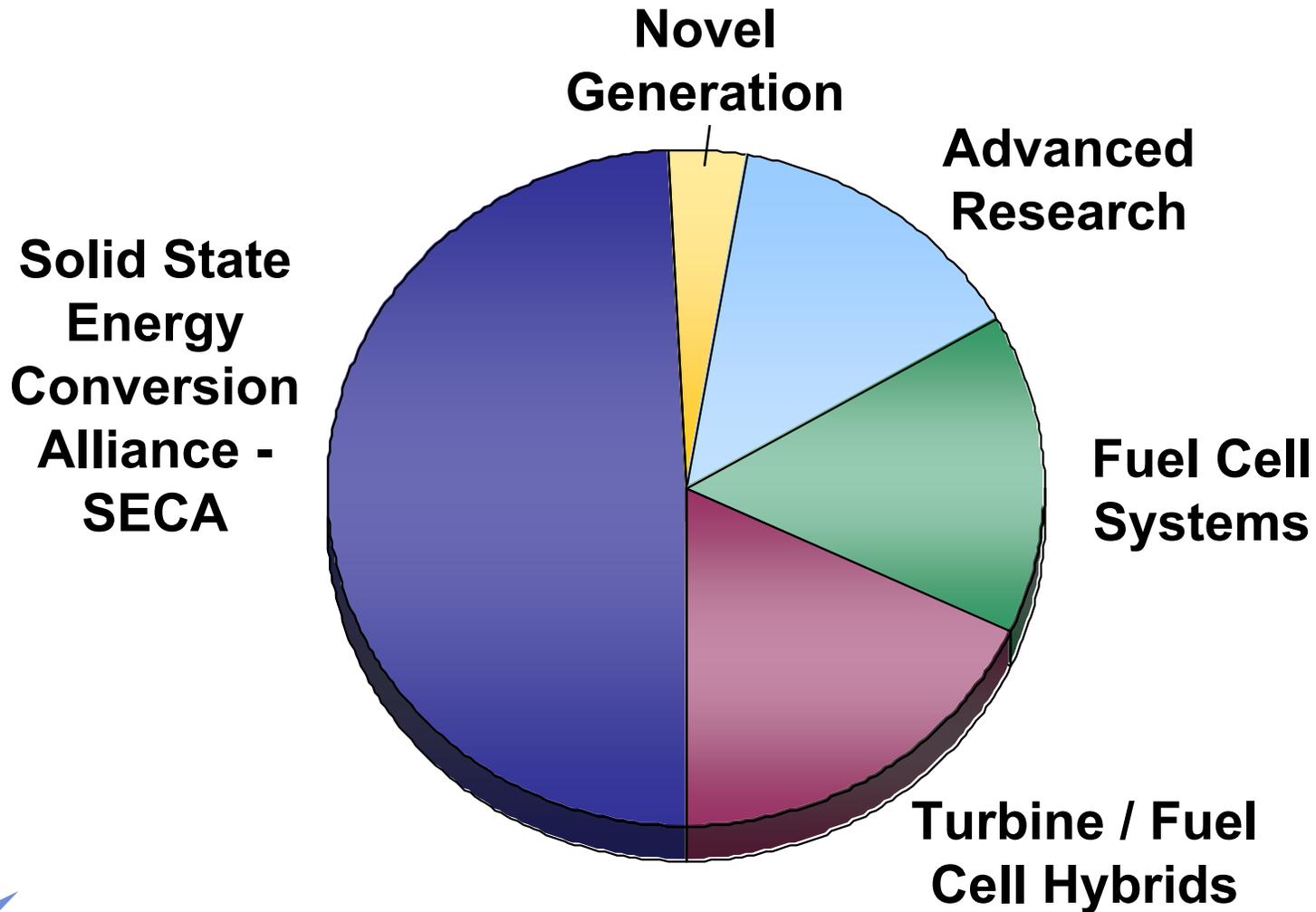
- Hybrid turbine / fuel cell systems for zero carbon emission coal gasification systems

- *Lower cost*
- *Higher reliability*



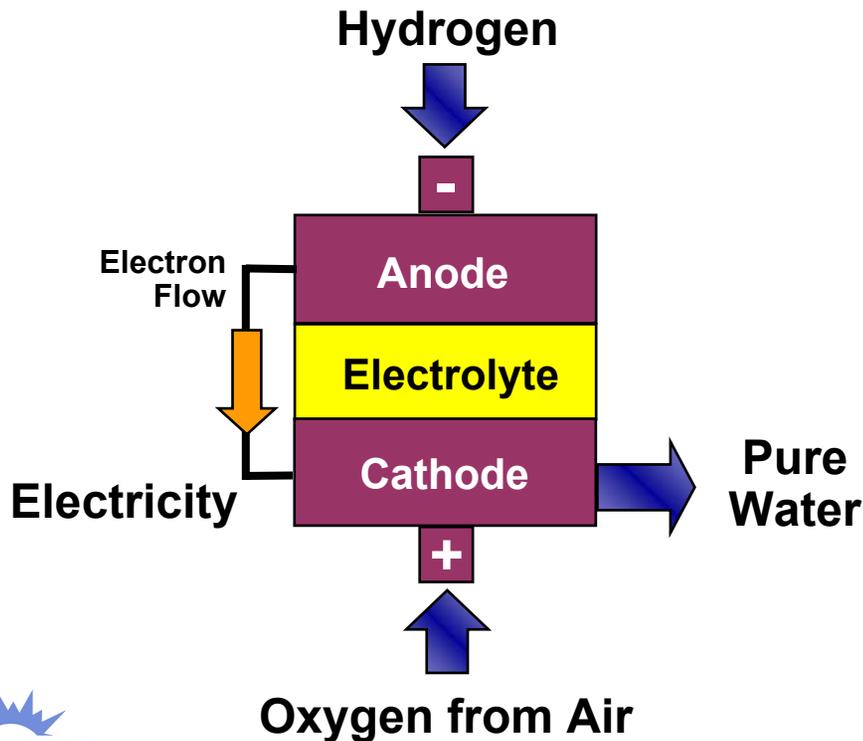
# Fuel Cell R&D Portfolio

*35 Projects - \$71M FY 04 Funding*



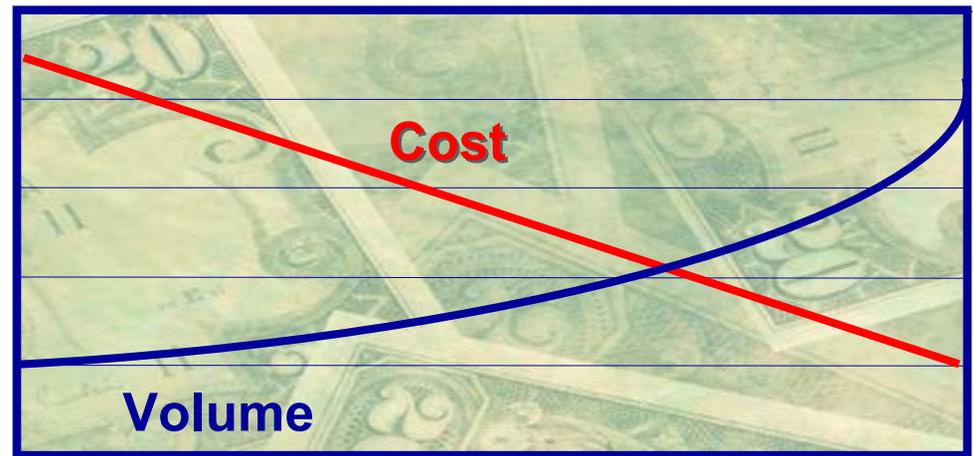
# Cost Is the Issue!

- Fuel cells cost \$1,600 – \$4,500 per kilowatt
- Ten-fold cost reduction for large scale deployment



# Solid State Energy Conversion Alliance (SECA) *Program Strategy*

- Start with end in mind (\$400 / kW 3-10 kW systems by 2010)
- High-volume / low cost manufacturing technology
- Make public benefits of fuel cells widely available



**Low Cost / High Volume**  
**\$400 / kW > 100,000 units / yr**

# SECA: A Route to Making Fuels Cells a Reality



**2005**

- **1<sup>st</sup> Generation products**
  - Premium power
  - Truck APU's
  - Military

**2010**

- **\$400/kW**
- **Commercial products**
  - Residential, commercial, industrial CHP

**2015**

- **\$400/kW**
- **Hybrid systems**
- **Coal power plants**



# SECA Industrial Teams

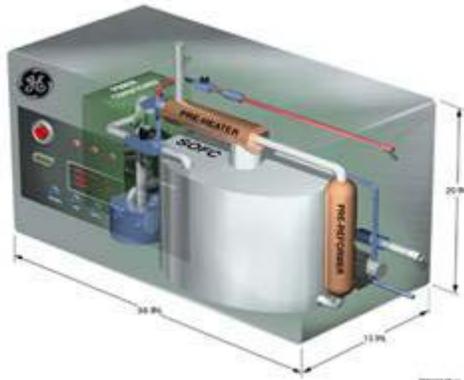
 FuelCell Energy



**DELPHI** **Battelle**  
Driving Tomorrow's Technology



 General Electric Company



**SIEMENS**  
Westinghouse



**Acumentrics**  
Advanced Power & Energy Technologies



 **Power Generation**

**SOFCo**  
EFC Holdings, LLC  
Solid Oxide Fuel Cells and Fuel Processors



# Siemens Westinghouse 5-kW System



Data display

10-kW DC/AC inverter

Inlet air filter

Control computer and electronics

Lead/acid battery pack

Exhaust heat exchanger

SW 5-kW cell stack

Gas control valve for start-up heater

Gas shut-off valve for start-up heater

Desulfurizer

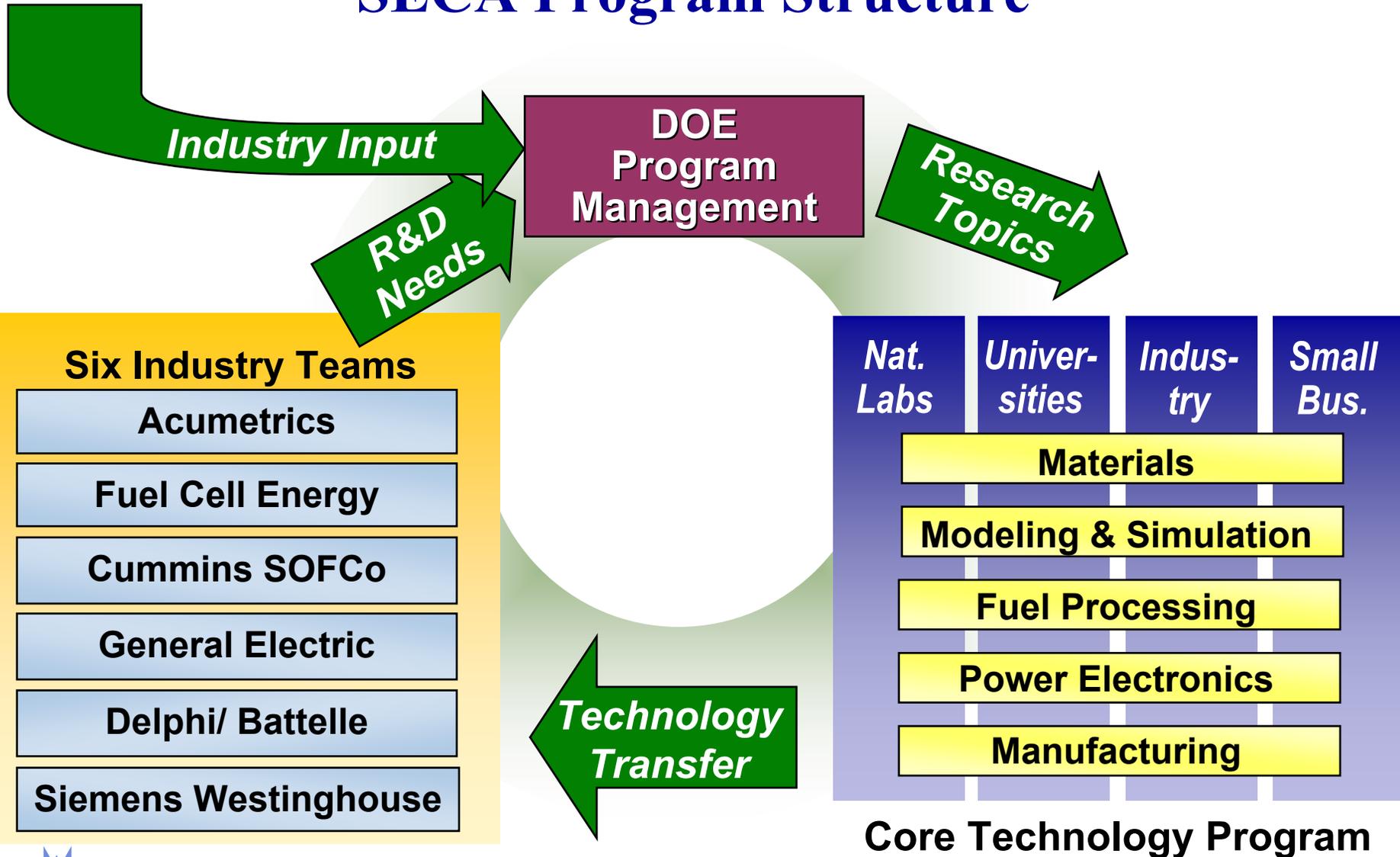
Cell stack gas control valve

Cell stack gas shut-off valve

Primary and backup air blowers

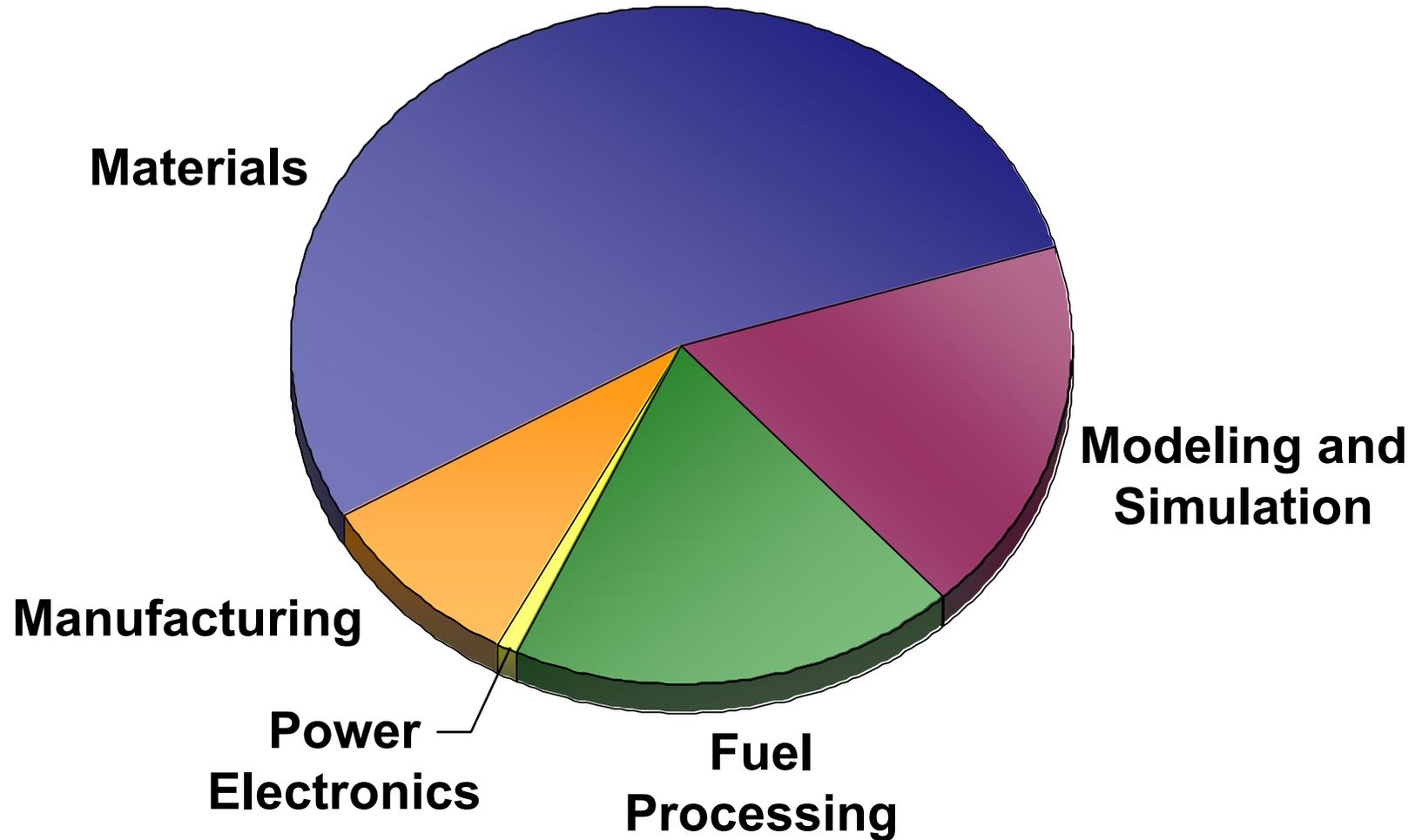


# SECA Program Structure



# SECA Core Technology Portfolio

*\$16M FY 04 Funding*



# SECA Participants

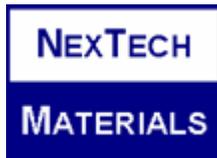
## *Universities, National Labs, Industry*



UNIVERSITY OF WASHINGTON



MONTANA STATE UNIVERSITY



UNIVERSITY OF FLORIDA



# FutureGen

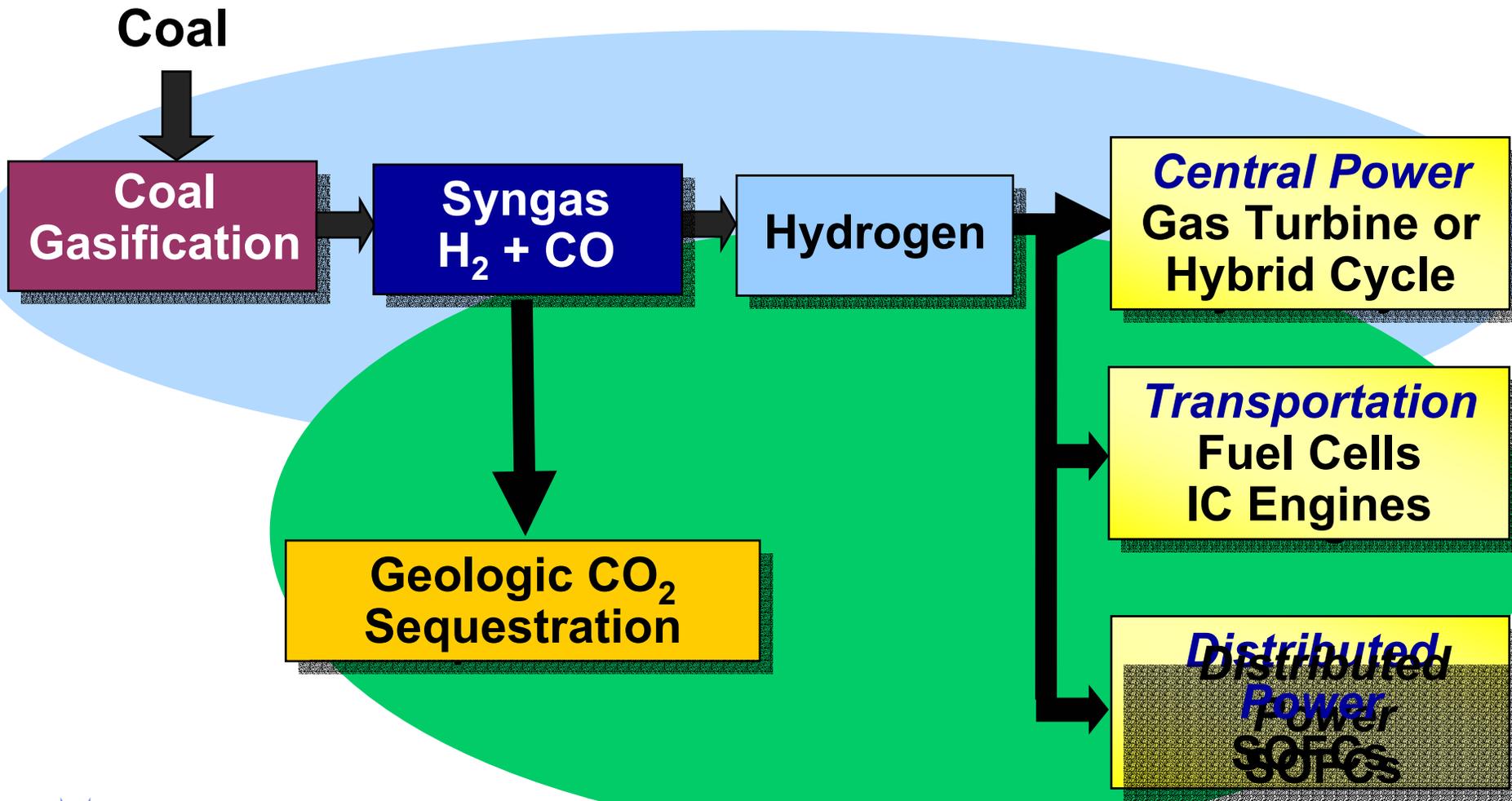
## *Sequestration & Hydrogen Research Plant*

**“ ... the United States will sponsor a \$1 billion, 10-year demonstration project to create the world's first coal-based, zero-emissions electricity and hydrogen power plant ... ”**

***February 27, 2003***



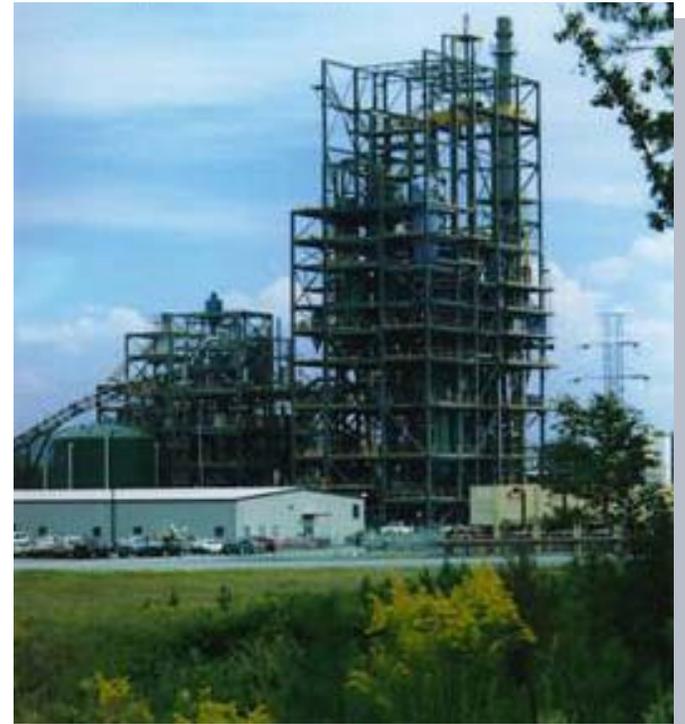
# Fuel Cells in FutureGen



# Fuel Cell Demonstrations on Coal Gas



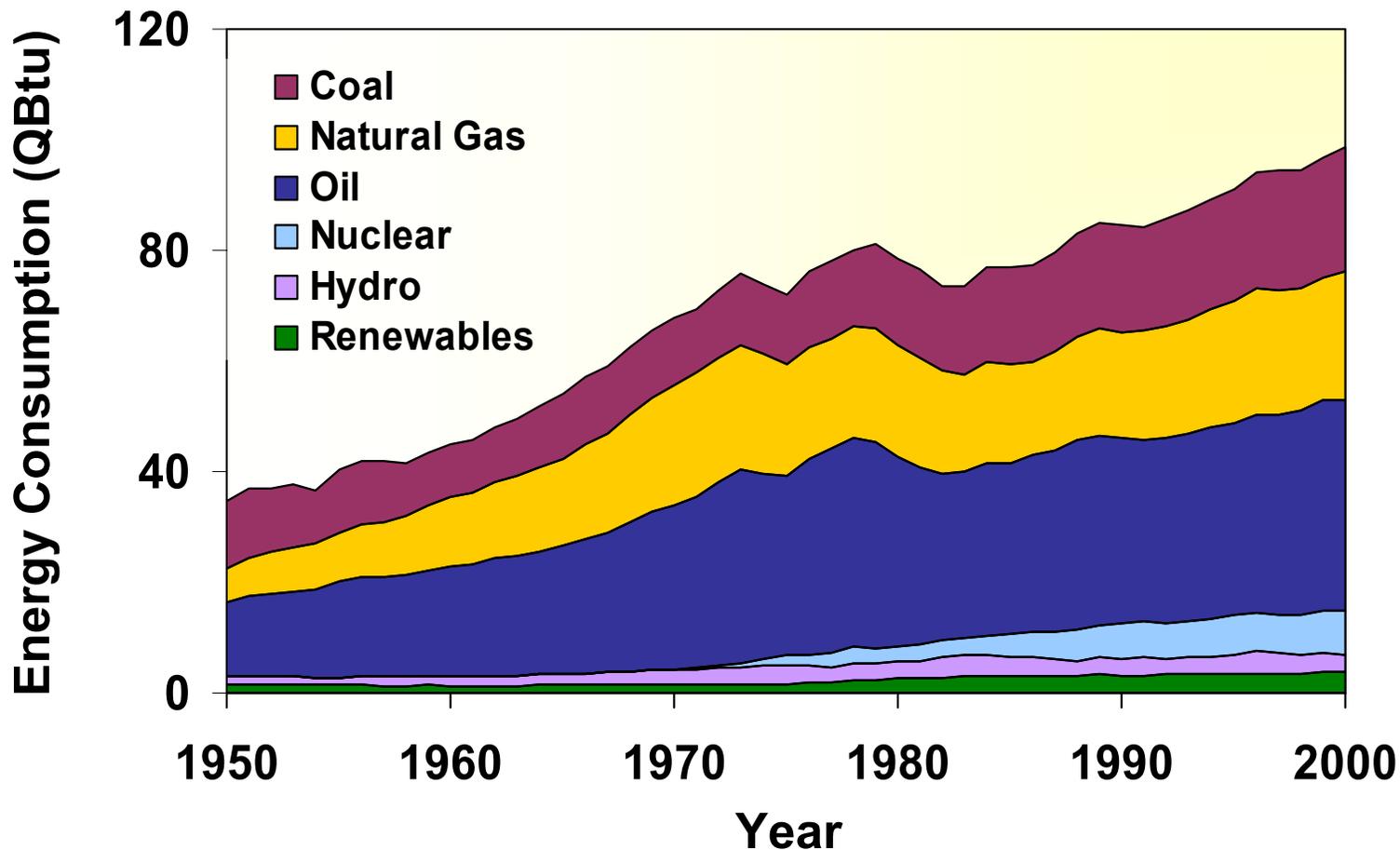
*FuelCell Energy's 2-MW fuel cell at Wabash River coal gasification plant, Terre Haute, IN*



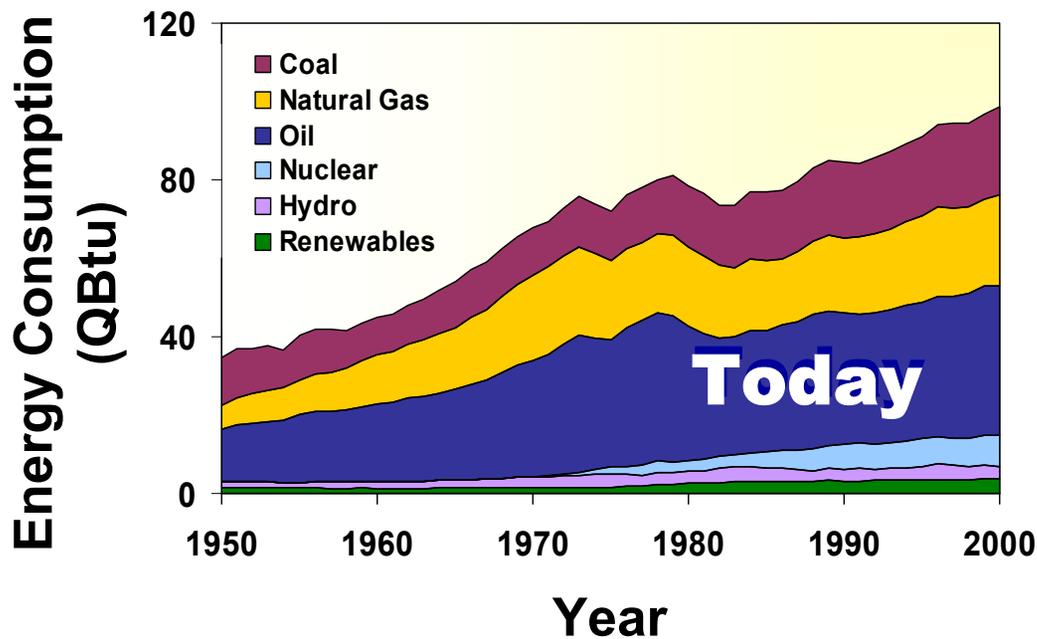
*Delphi SECA unit at Southern Company's Power system Development Facility, Wilsonville, AL*



# U.S. Energy Today



# Providing Options for the U.S. Energy Future



**Future  
Clean  
Affordable  
Reliable  
Energy  
Supply**

# Structural Shift in Natural Gas Markets

