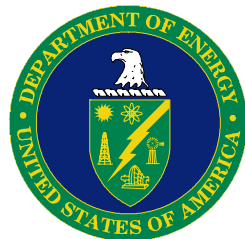


# Department of Energy Carbon Capture and Storage Program



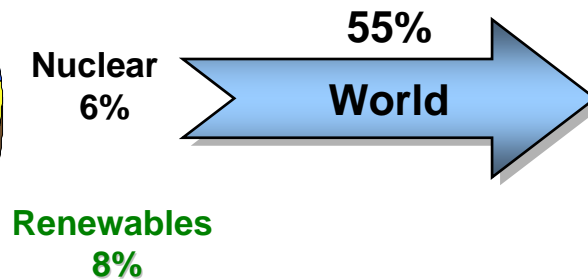
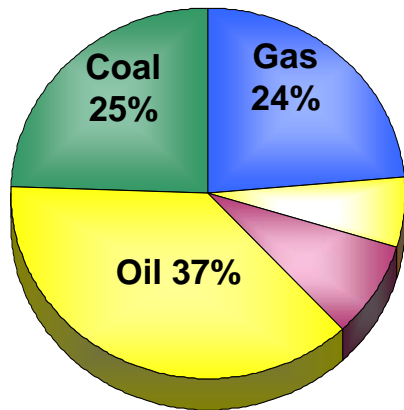
**Jarad Daniels**  
**Office of Fossil Energy**  
**February 17, 2009**



# Growing World Energy Demand

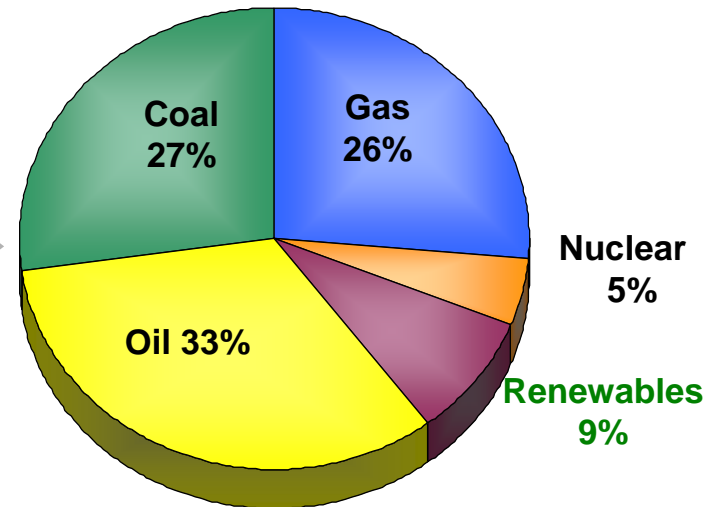
**World Energy Consumption 2006**

465 QBtu or 490 EJ  
86% Fossil Energy



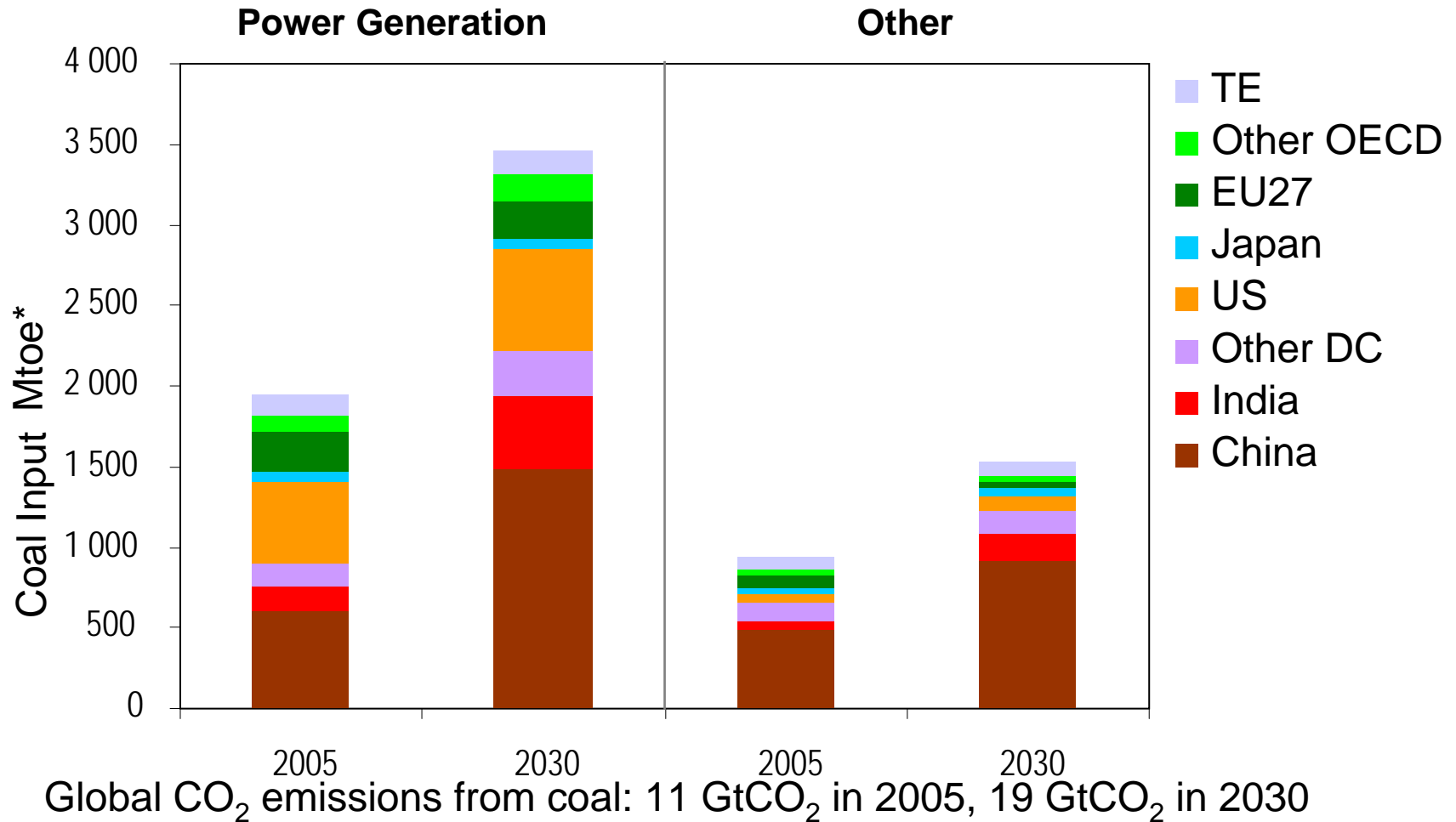
**World Energy Consumption 2030**

722 QBtu or 761 EJ  
87% Fossil Energy



World today and tomorrow data from EIA AEO 2007.

# Importance of Coal World-Wide



\* Mtoe: Million metric tonnes oil equivalent

Source: IEA, World Energy Outlook 2007, Reference Scenario.



# DOE Clean Coal Program

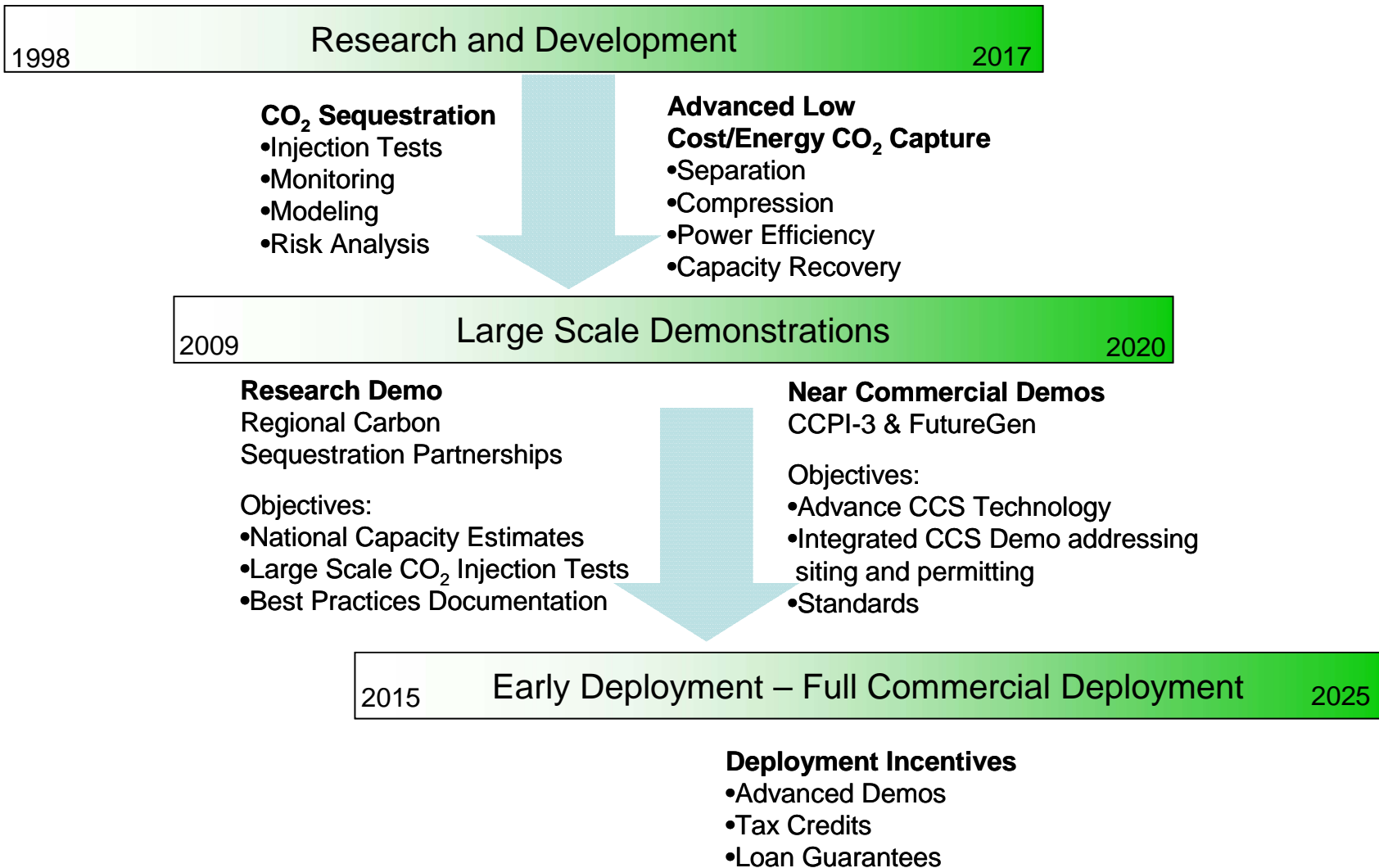
## *What Are We Doing?*

### **Driving to low cost, reliable, near-zero emissions systems:**

- Developing a portfolio of key technologies to reduce costs and increase efficiency (e.g., membrane separation, advanced gasification, etc.)
- Conducting integrated research, development and demonstration (RD&D) from breakthroughs and innovations, through engineering development, to commercial demonstrations.
- Addressing the cost, safety, and permanence of geologic storage through public/private Carbon Sequestration Regional Partnerships.
- Supporting early commercial deployments through incentives (e.g., investment tax credits, loan guarantees.)

# Near Zero Emissions Coal

## Safe and Effective CCS Technology Deployment



# Clean Coal Funding, FY08-FY09

(\$ in Thousands)	FY 2008 Adjusted B/A	FY 2009 House Marks	FY2009 Senate Marks
CLEAN COAL POWER INITIATIVE	69,363	241,000	232,300
FUTUREGEN	74,317		0
FUELS AND POWER SYSTEMS			
Innovations for Existing Plants	36,081	40,000	50,000
Advanced Integrated Gasification Combined Cycle	53,509	60,000	63,000
Advanced Turbines	23,782	24,000	30,000
Carbon Sequestration	118,908	220,000	149,132
Fuels	24,773	10,000	30,000
Fuel Cells	55,490	60,000	60,000
Advanced Research	37,159	26,600	30,000
<b>Subtotal, Fuels and Power Systems</b>	<b>349,702</b>	<b>440,600</b>	<b>412,132</b>
<b>TOTAL COAL R&amp;D</b>	<b>493,382</b>	<b>681,600</b>	<b>644,432</b>

# Stimulus Funding Summary

<b>Program/Project Activity</b>	<b>Amount(\$M)</b>
Fossil Energy R&D	1,000
CCPI-3	800
New Solicitation - CCS Projects and Industrial Applications	1,520
Regional Partnerships - Site Characterization	50
Geologic Sequestraion Training and Research Grants	20
Fossil Energy Program Direction	10
<b>Total</b>	<b>3,400</b>



# Sequestration Challenges

**Sequestration (Geologic) = Capture, Transport and Storage (CCS)**

## Technical & Economic Challenges

- **Current capture technologies are expensive and energy intensive and compression to high pressures (~2000 psi) to liquefy CO<sub>2</sub>. Need to bring down cost and reduce energy penalty associated with CO<sub>2</sub> separation and compression.**
- **Scale up and integrate CCS into power plants.**
- **Identifying best practices for CO<sub>2</sub> injection based on applicability of Oil and Gas industry experience.**
- **Monitoring, Mitigation and Verification of long-term storage**
- **Scaling up and integrating capture and storage technologies**



# Sequestration Challenges

## Non- technical Challenges

- **Policy Issues and Acceptance of Geologic Storage**
  - Currently no compensatory policy framework for carbon
  - “Proving” safe and effective long-term geologic storage
  - Transport of CO<sub>2</sub> is likely by pipeline a cost (and right-of – way) issue for pipeline infrastructure to be built.
- **Financing CCS projects absent legal framework**
- **Legal & Regulatory issues:**
  - Legal framework for CO<sub>2</sub> not in place;
  - subsurface rights;
  - long-term storage liability issues remain to be resolved

# Regional Carbon Sequestration Partnerships

**Creating Infrastructure for Wide Scale Deployment:**

## Characterization Phase

- 24 months (2003-2005)

## Validation Phase

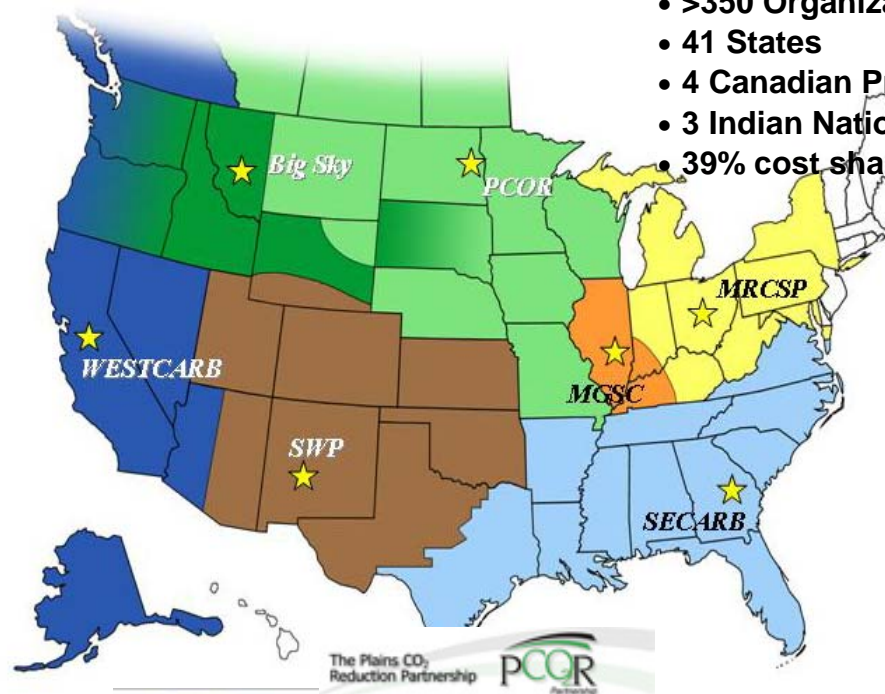
- 4 years (2005 - 2009)
- 7 Partnerships (41 states)
- 25 Geologic field validation tests

## Deployment Phase

- 10 years (2008-2017)
- Several large injection tests in different geology

### Representing:

- >350 Organizations
- 41 States
- 4 Canadian Provinces
- 3 Indian Nations
- 39% cost share



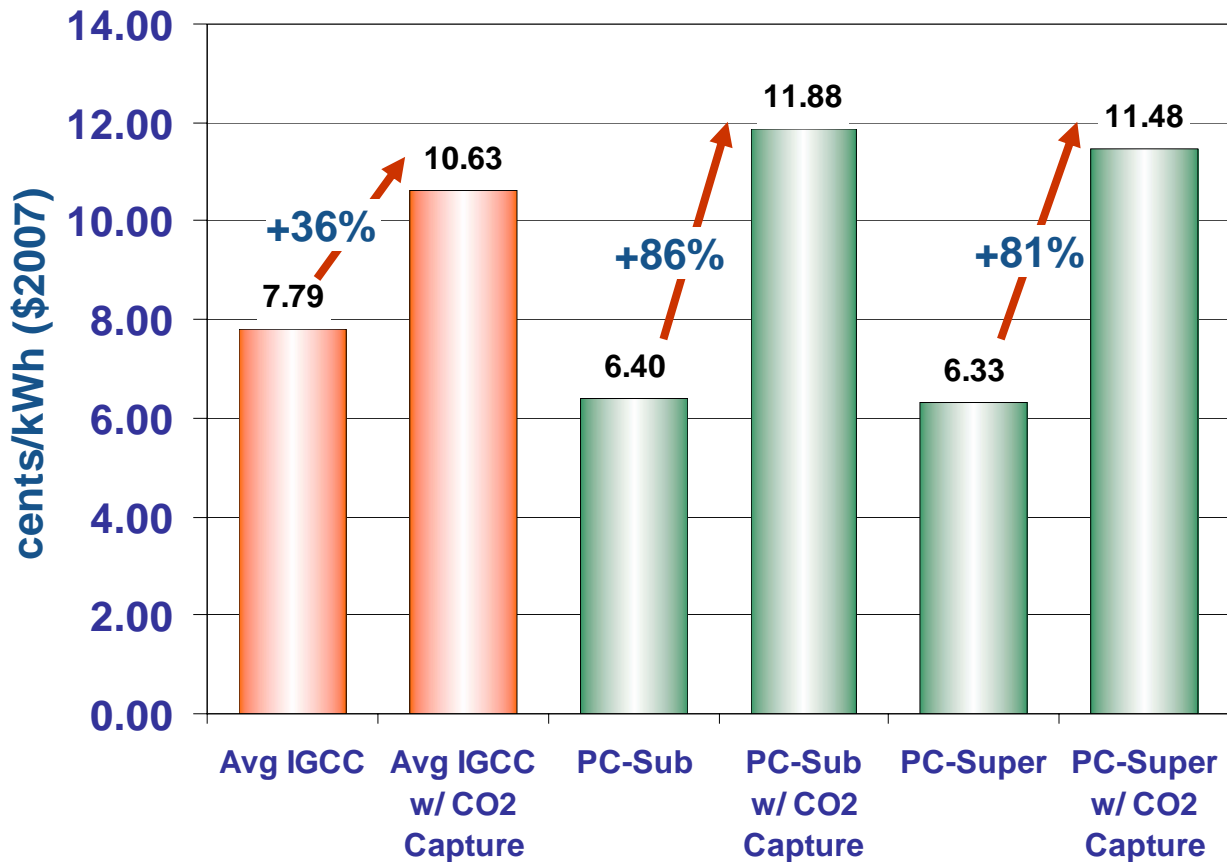
# Regional Partnership Goals

- **Develop necessary infrastructure to demonstrate large-scale geological sequestration technologies across North America.**
- **Demonstrate safe CO<sub>2</sub> storage during pilot- & large-scale injection tests.**
  - Verify plume location via monitoring
  - Predict plume fate via modeling
- **Generate results that assist regulators & policy makers.**



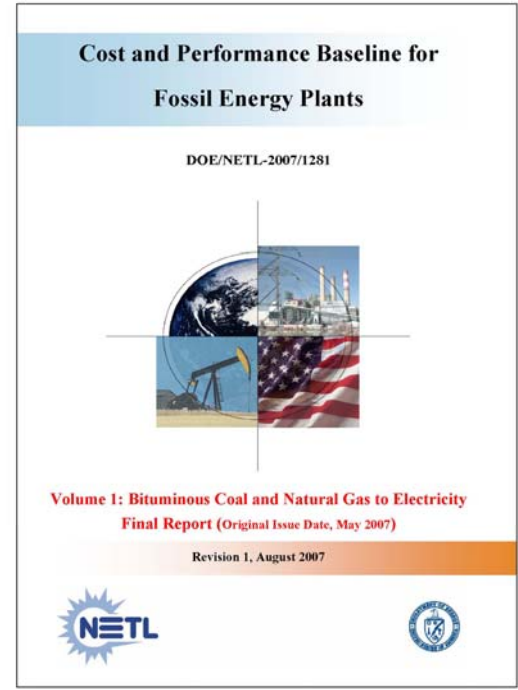
# Cost of Electricity Comparison -- New Plants

(Baseline Study – Bituminous Coal)

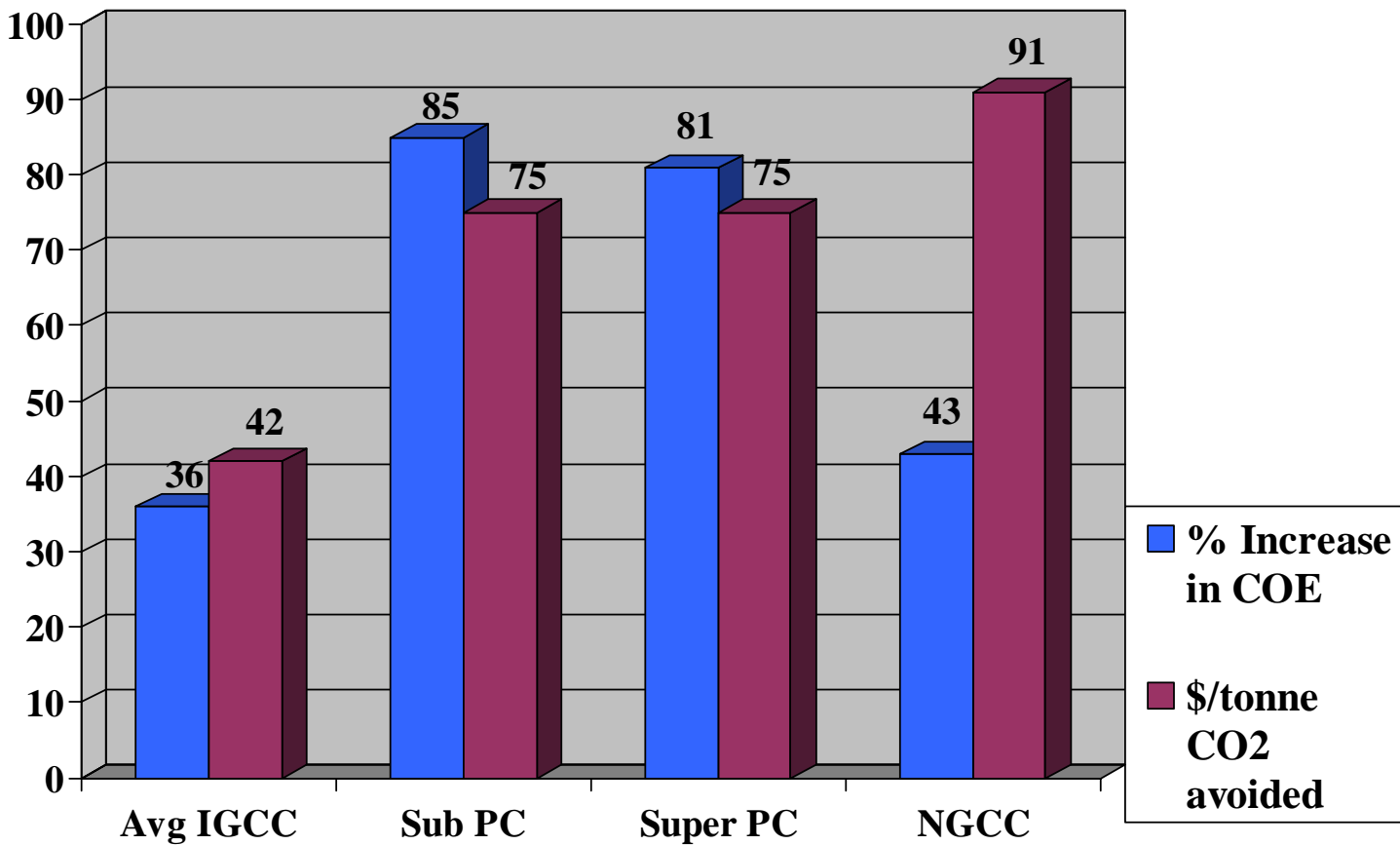


January 2007 Dollars, Coal cost \$1.80/10<sup>6</sup> Btu

DOE/NETL Report: "Cost and Performance Baseline for Fossil Energy Plants", May 2007



# CO<sub>2</sub> Mitigation Costs



# US DOE's Clean Coal Technology Goals



## ➤ 2010:

- 45-50% Efficiency (HHV)
- 99% SO<sub>2</sub> removal
- NO<sub>x</sub> < 0.01 lb/MM Btu
- 90% Hg removal

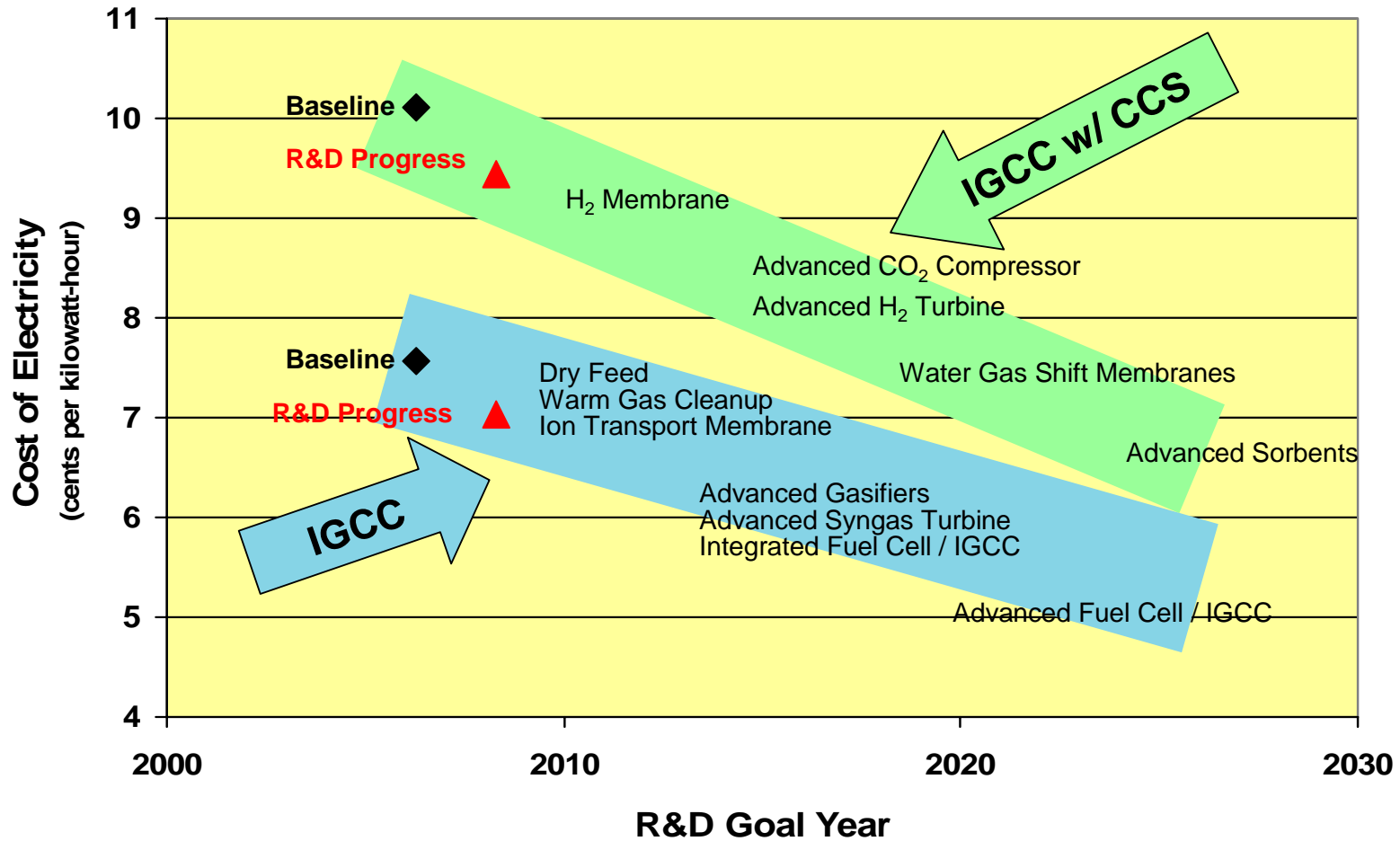
## ➤ 2012:

- 90% CO<sub>2</sub> capture
- <10% increase in cost of electricity (COE) with carbon sequestration for IGCC-CCS

## ➤ 2015

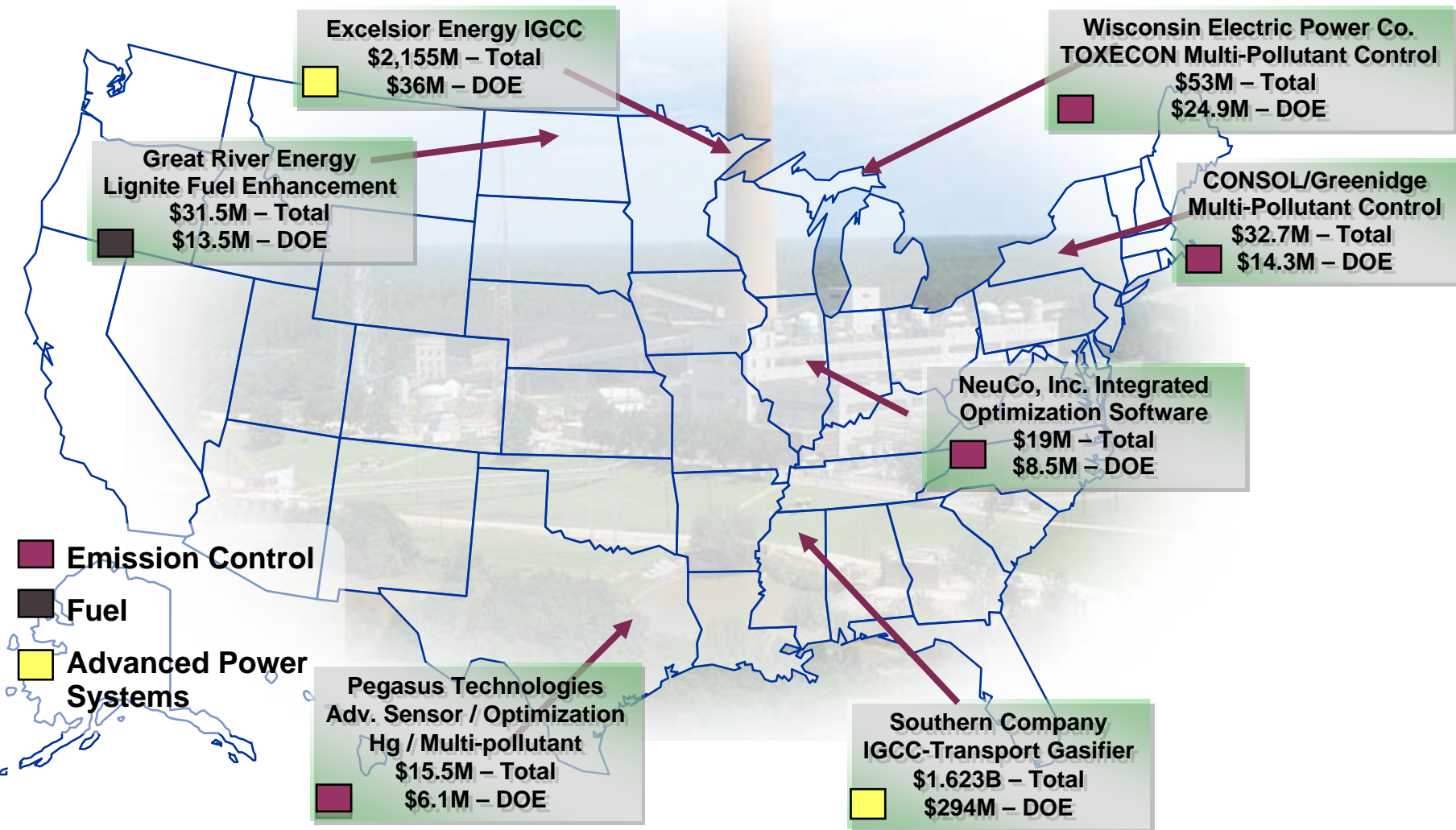
- Multi-product capability (e.g., power + H<sub>2</sub>)
- 60% efficiency (measured without carbon capture)

# Future of Coal Based Power



# PPII & CCPI Demonstration Projects

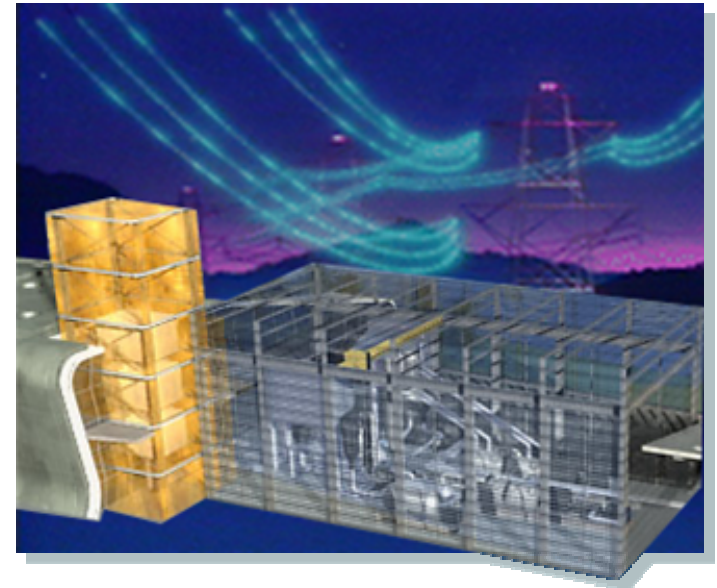
## Locations & Cost Share



# FutureGen Objectives

**Near zero-emissions,  
coal-based power plant to:**

- **Emit virtually no air pollutants**
- **Capture & permanently sequester at least 1 million metric tons/year CO<sub>2</sub>**
- **Integrate full-scale operations – a key step**
- **Serve as a test facility for emerging technologies**





# Final Observations

- **CCS technology is available today, however:**
  - It is very expensive, energy intensive, and not fully proven
- **Sequestration needs to be more widely demonstrated, especially in deep saline reservoirs with large-volume CO<sub>2</sub> injection**
- **DOE RD&D program is targeting the key issues**
- **Regulatory certainty is a prerequisite for commercial action.**