



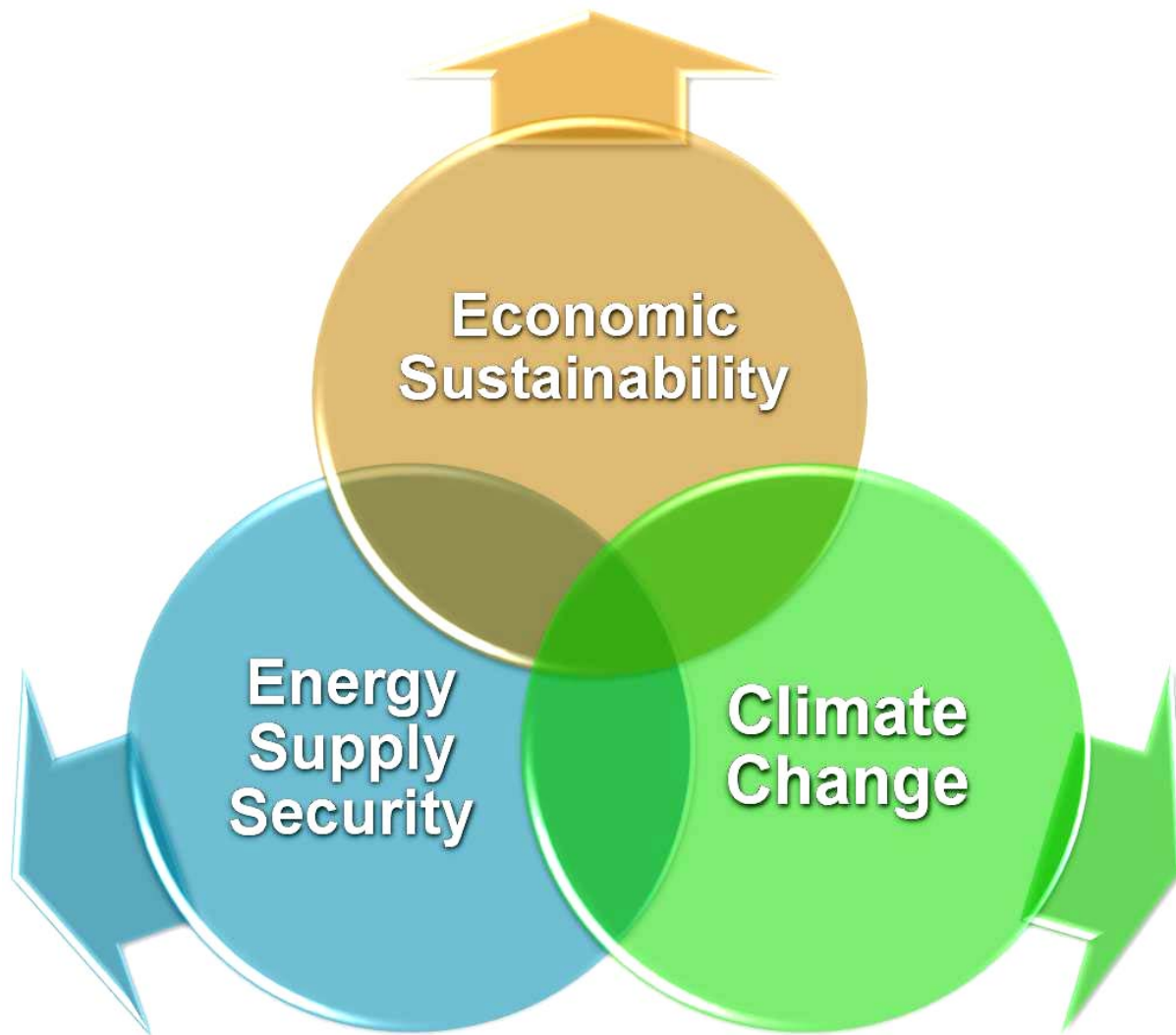
DOE Perspective on Coal CCS

Joseph P. Strakey

Chief Technology Officer



Energy Strategy Complexity



Observations from CO₂-Energy Modeling

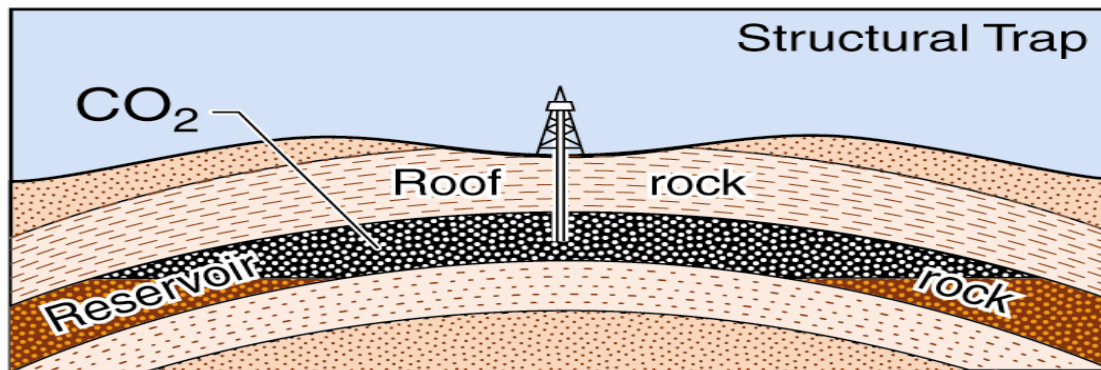
- Economy wide, the majority of carbon emission reductions over the next several decades are expected to occur in the electric power sector, primarily from reduced use of conventional coal plants.
- Model predictions of reductions in coal use are sensitive to the relative pricing of coal with CCS vs. nuclear, and assumptions for demand reductions through energy efficiency.
- Internal DOE analysis indicates that coal with CCS (and to a lesser extent gas with CCS) will contribute significantly to our electricity supply in 2030.
- Looking out on a path to long-term stabilization at 450ppm CO₂ (~ 519 to 558ppm CO₂-e), modeling by DOE's shows that coal with CCS and gas with CCS continue to play a role in 2050 and beyond.
- The availability of CCS and nuclear technologies have a significant impact on allowance prices; these technologies must be developed, demonstrated, and deployed on a large scale before 2030.

CCS Experience

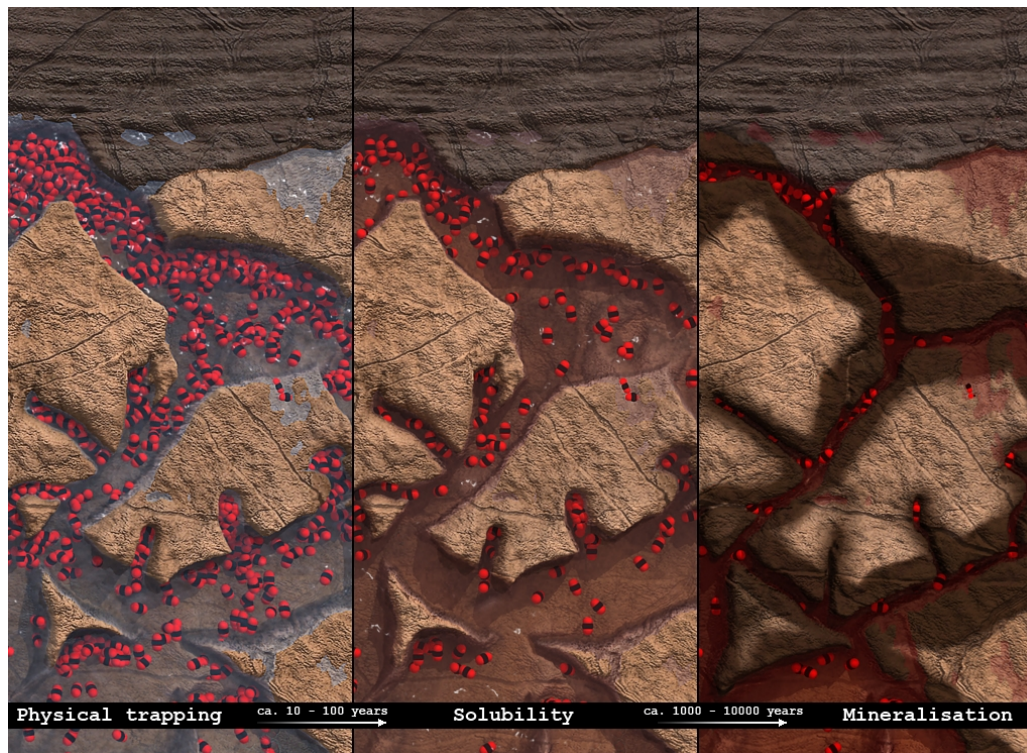
- **Carbon capture technology is commercially available**
 - Post-combustion capture at 20-80 MWe
 - Pre-combustion (gasification) capture at full scale
- **CO₂ injection into geologic formations is widely practiced today**
 - EOR: 48 million TPY in 2007
 - 50 Acid gas injection projects
 - Megaton/yr injection projects
 - Weyburn-Midale
 - Sleipner
 - In Salah



Carbon Storage Mechanisms



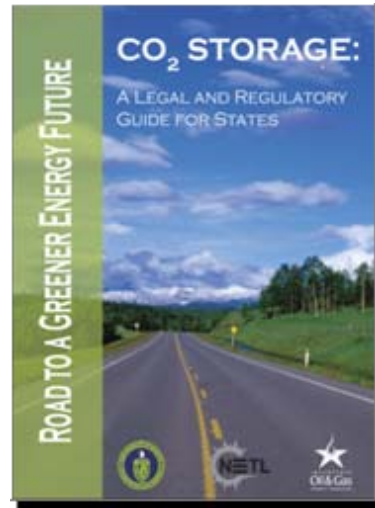
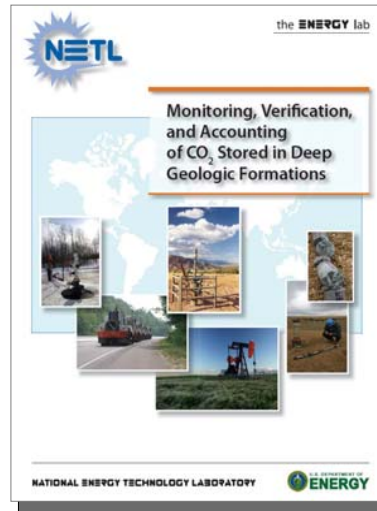
- **Physical trapping**
- **Residual phase trapping**
- **Solution Trapping**
- **Mineralization**



Key Challenges for CCS

Technical Issues

- **Capture Technology**
 - Existing Plants
 - New Plants (PC)
 - IGCC
- **Cost of CCS**
- **Sufficient Storage Capacity**
- **Permanence**
- **Best Practices**
 - Storage Site Characterization
 - Monitoring/Verification
 - Modeling



Legal/Social Issues

- **Regulatory Framework**
 - Permitting
 - Treatment of CO₂
- **Legal Framework**
 - Liability
 - Ownership
 - Pore space
 - CO₂
- **Infrastructure**
- **Human Capital**
- **Public Acceptance**

Regional Carbon Sequestration Partnerships

- *Engage regional, state, and local governments*
- *Determine regional sequestration benefits*
- *Baseline region for sources and sinks*
- *Establish monitoring and verification protocols*
- *Address regulatory, environmental, and outreach issues*
- *Validate sequestration technology and infrastructure*

- *7 Regional Partnerships*
- *43 States, 4 Canadian Provinces*
- *350+ distinct organizations*

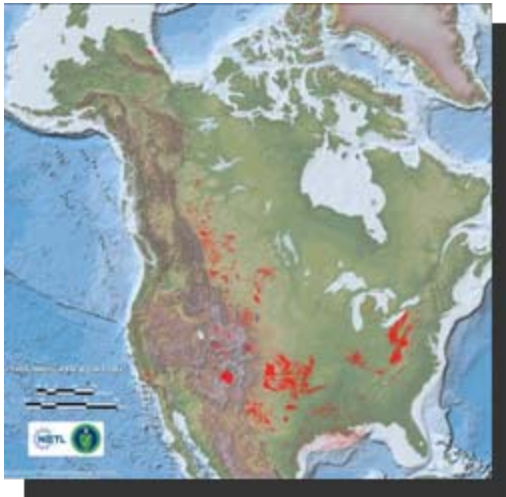
Developing the Infrastructure for Wide-Scale Deployment



National Atlas Highlights (Atlas II)

Adequate Storage Projected

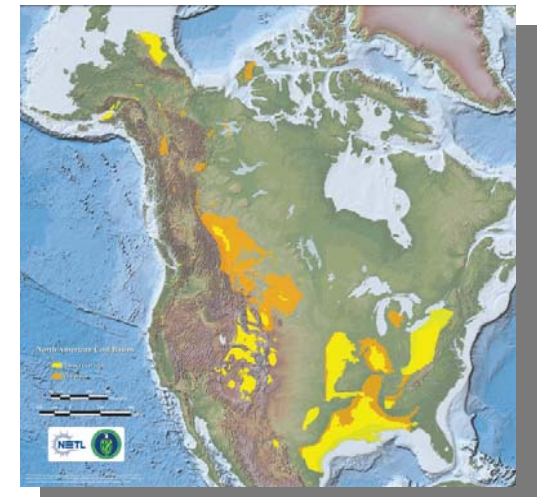
Emissions ~ 3.8 GT CO₂/yr point sources



Oil and Gas Fields



Saline Formations



Unmineable Coal Seams

*North American CO₂ Storage Potential
(Gigatons)*

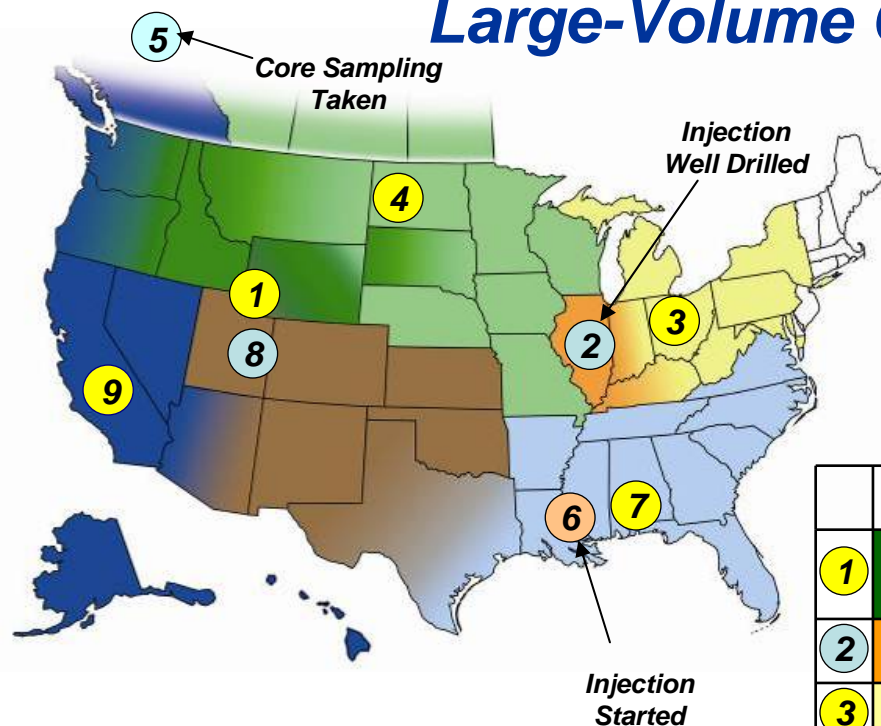
**Conservative
Resource
Assessment**

Sink Type	Low	High
Saline Formations	3,300	12,600
Unmineable Coal Seams	160	180
Oil and Gas Fields	140	140

**Hundreds of
Years of
Storage
Potential**

RCSP Phase III: Development

Large-Volume Geologic Field Tests



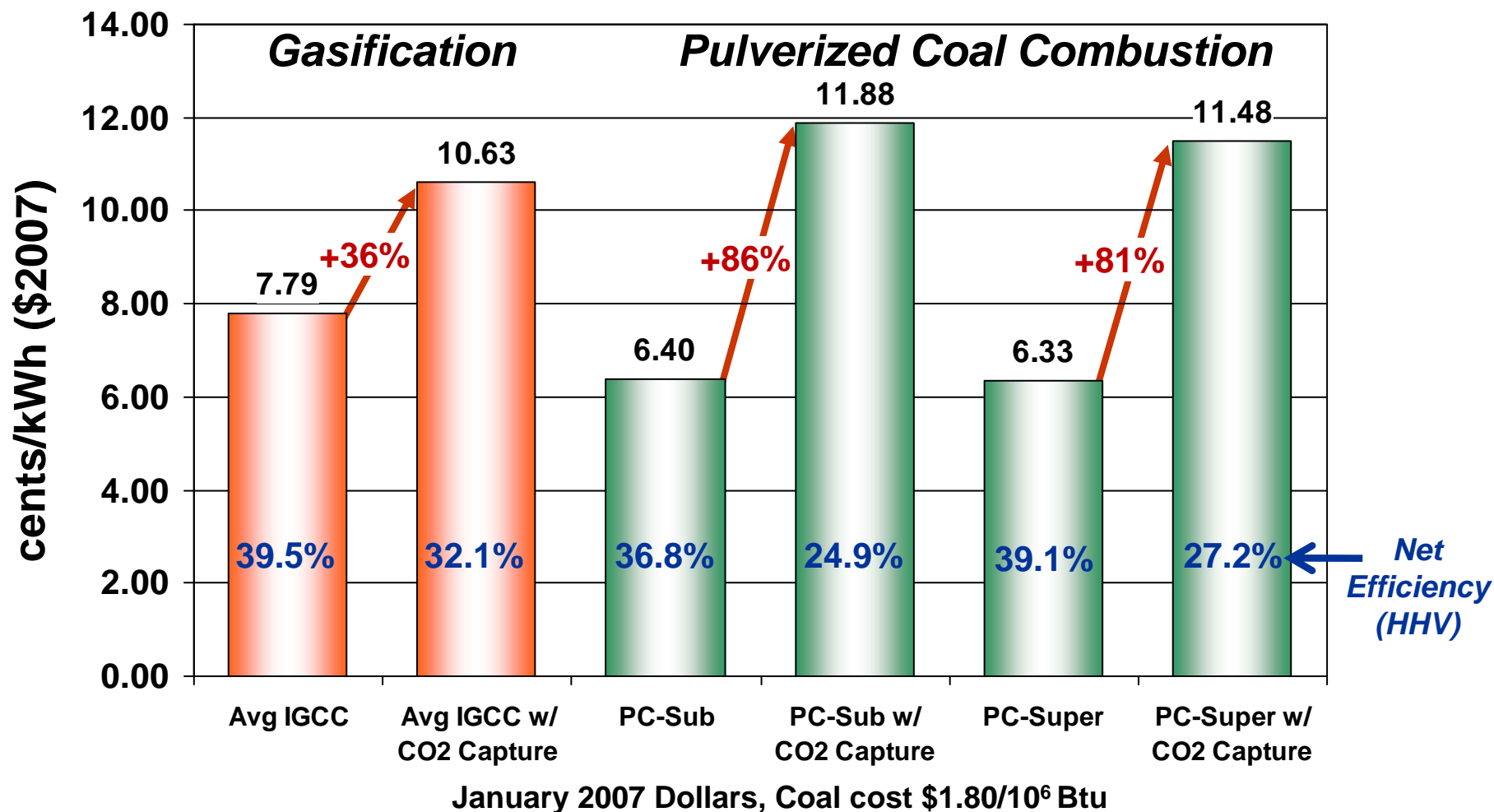
- 2009 Injection Scheduled
- 2010 Injection Scheduled
- 2011 Injection Scheduled

- ✓ *Nine large-volume tests*
- ✓ *Injections initiated 2009 – 2011*

	Partnership	Geologic Province	Type
1	Big Sky	Triassic Nugget Sandstone / Moxa Arch	Saline
2	MGSC	Deep Mt. Simon Sandstone	Saline
3	MRCSP	Shallow Mt. Simon Sandstone	Saline
4	PCOR	Williston Basin Carbonates	Oil Bearing
5		Devonian Age Carbonate Rock	Saline
6	SECARB	Lower Tuscaloosa Formation Massive Sand Unit	Saline
7			
8	SWP	Regional Jurassic & Older Formations	Saline
9	WESTCARB	Central Valley	Saline

Cost of Electricity Comparison -- New Plants

(NETL Baseline Study)



DOE Coal RD&D Program

- **Overall Coal Program goal (deployment in 2020):**

- >90% CO₂ capture

- <10% increase in cost of electricity (COE) with CCS

- **Sequestration Program goal (2012):**

- ✓ 90% CO₂ capture

- ✓ 99% storage permanence

- ✓ < 10% increase in COE
(*new plants -- pre-combustion capture*)

- ✓ < 35% increase in COE
(*existing plants -- post- and oxy-combustion*)

- ✓ ±30% storage capacity estimates

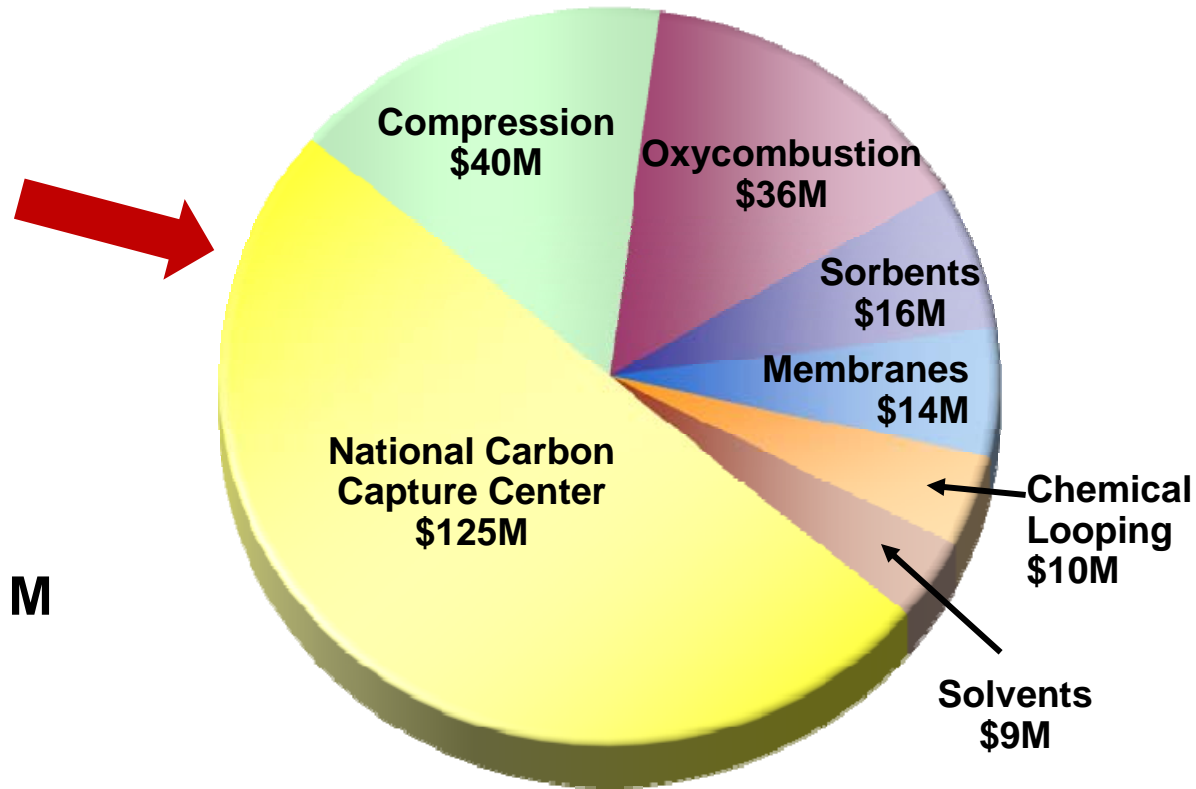


Coal – CCS RD&D Budget

**Total FY 2009 Program
Funding: \$692 M**

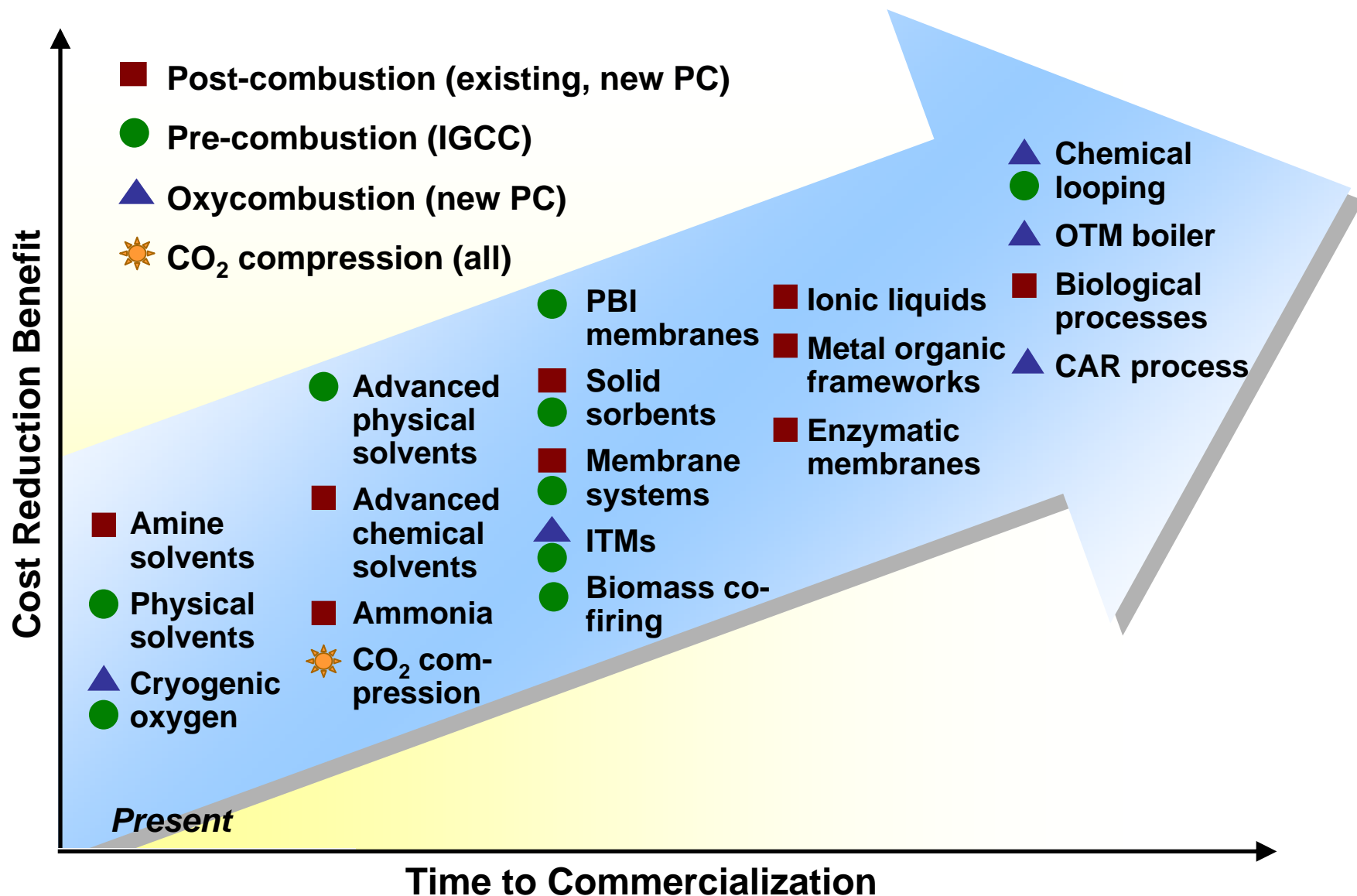
- Sequestration: \$150 M
- Existing Plants: \$50 M**
- Gasification: \$65 M
- Turbines: \$28 M
- Fuel Cells: \$58 M
- Fuels: \$25 M
- Advanced Research: \$28 M
- CCPI: \$288 M
- FutureGen: \$0 M

Existing Plants Portfolio (Multiyear)



**27 Active Projects
Total Value = \$250M
DOE Share = \$170M**

Advancing Carbon Capture Technologies



Clean Coal Power Initiative Round 3 (CCPI-3)

- **Objective**

- Demonstrate coal-based technologies that capture & sequester, or put to beneficial reuse, CO₂ emissions at commercial scale

- **Requirements**

- Pre-combustion, post-combustion, oxy-combustion
- Geologic storage in saline aquifer, EOR, coal seams, basalt, stacked storage
- $\geq 300,000$ tons CO₂ per year
- *1st closing date - Jan 20, 2009*
 - *Capture > 90%; Coal use > 75%*
- *2nd closing date - Aug 24, 2009*
 - *Capture > 50%, target 90%; Coal use > 55%*
- Targeting COE increases of
 - *< 10% for gasification; < 35% for combustion & oxy-combustion*

- **Status**

- \$1.436 billion available, including \$800 million in ARRA funds
- 1st group of applications received Jan 20, 2009
 - *Two selections made in June 2009*
- 2nd group of applications due Aug 24, 2009

CCPI-3: Hydrogen Energy International

IGCC with Hydrogen Turbine and Full Integrated CCS

- **257 MWe (net) IGCC in Kern County, CA**
- **90% CO₂ capture**
- **2 million TPY sequestered in EOR**
- **\$2.6 billion
(DOE \$308 million)**
- **Construction starts,
March 2011**
- **Demonstration starts
2015**



CCPI-3: Basin Electric Power Cooperative

Post-Combustion CO₂ Capture and Sequestration

- Antelope Valley Station (AVS) near Beulah, ND
- 120 MW-equivalent slipstream from AVS Unit 1
- 90% CO₂ capture
- 1 million TPY sequestered in EOR
- \$300 million
(DOE \$100 million)
- Construction starts
February 2010
- Demonstration starts
January 2013



Fossil Energy Recovery Act Provisions

<i>Fossil Energy (\$ in Millions)</i>	<i>Funding Amount</i>
<i>Fossil Energy Research and Development</i>	<i>\$1,000</i>
<i>Clean Coal Power Initiative – Round 3 FOA</i>	<i>\$800</i>
<i>Industrial Carbon Capture Solicitation</i>	<i>\$1,520</i>
<i>Geologic Formation Site Characterization</i>	<i>\$50</i>
<i>Geologic Sequestration Training & Research</i>	<i>\$20</i>
<i>Program Direction</i>	<i>\$10</i>
<i>Total, Fossil Energy</i>	<i>\$3,400</i>

American Recovery & Reinvestment Act of 2009

Industrial CCS (\$1.52 B)

- **Objectives**

- Capture 75% of the CO₂ from the treated industrial stream
- Store 1 million TPY of CO₂ in a saline formation or other value-added options
- Investigate novel CO₂ use / reuse technologies

- **Planned Competitive Awards**

- Large-Scale CCS Projects (1.32 B)
- Innovative Concepts for Beneficial CO₂ Use (\$100 M)

- **Staged Competition**

- Phase I Project Feasibility/Definition
- Competitive down-select after 7 months
- Award Phase II projects by Sept. 30, 2010
- Complete by September 2015

- **Cost Share**

- Private cost share \geq 20%
- Target 50% for commercial scale projects,

FutureGen Restart

- **New Limited Scope Cooperative Agreement (7/09 – 3/10)**
 - Preliminary Design, Revised Cost Estimate & Funding Plan
 - Rapid restart of preliminary design activities.
 - Completion of a site-specific preliminary design and updated cost estimate.
 - Expansion of the Alliance sponsorship group.
 - Development of a complete funding plan.
 - Potential additional subsurface characterization.
 - Key Deliverables
 - Revised cost estimate
 - Alliance funding plan
 - Estimated Cost \$17.8 Million (\$14.3 M DOE share)
- **Go/No-Go Decision 1/29/2010**
 - \$1.073 Billion maximum DOE contribution for remainder of project
 - Project currently estimated at ~\$2.4 Billion



More Information on Our Websites

NETL
www.netl.doe.gov

Office of Fossil Energy
www.fe.doe.gov

National Energy Technology Laboratory

Site Map

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NETL

THE ONLY U.S. NATIONAL LABORATORY DEVOTED TO FOSSIL ENERGY TECHNOLOGY

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TECHNOLOGIES

ENERGY ANALYSES

SOLICITATIONS & BUSINESS

CAREERS & FELLOWSHIPS

NEWSROOM

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NETL Researchers Develop Method to Estimate CO₂ Storage Capacity in Oriskany Formation

Robert Dilmore prepares an autoclave reactor used to measure the solubility of carbon dioxide in real brines of the Oriskany formation. [Read More!](#)

DOE Technology Monitors CO₂ Injection in Australian Gas Field

Australia has launched the first carbon sequestration project in the southern hemisphere with the help of technology developed by researchers at the U.S. Department of Energy. [Read More!](#)

Office of Fossil Energy Develops Educational Materials

Teaching students about fossil energy just got easier with the development of educational materials and classroom tools by DOE's Office of Fossil Energy.

Carbon Sequestration Partner Initiates CO₂ Injection into Michigan Basin

Tapping into a saline formation some 3,200 to 3,500 feet below the earth's surface, a DOE team of regional partners has initiated the injection of up to 10,000 metric tons of CO₂ to assess the formation's ability to store the greenhouse gas.

NETL Launches New Carbon Capture and Sequestration FAQ Portal

NETL is leading efforts to develop technologies to mitigate the emission of CO₂ – a major greenhouse gas and contributor to global climate change. A new [Carbon Capture and Sequestration FAQ Information Portal](#) has been developed to answer questions ranging from general background information, to details on the current status of various capture and sequestration technologies. This FAQ Portal is also a great place to find links to additional information sources.

PUBLICATIONS & PROJECTS // All >

- 2006 Annual Site Environmental Report
- netlinfo newsletter
- Oil & Natural Gas Supply
- Coal & Power Systems
- Carbon Sequestration
- Hydrogen & Clean Fuels

ARCHIVE // Go >

NEWS & FEATURES // All >

- April 2006 netlinfo
- Earth Day 2006 Poster Contest
- DOE Announces Restructured FutureGen Approach to Demonstrate Carbon Capture and Storage Technology at Multiple Clean Coal Plants
- NETL Earns Emergency Management Award
- Carl Bauer's Column Featured in "The Tennessean"

EVENTS CALENDAR // All >

- Seventh Annual Conference on Carbon Capture & Sequestration
- University Coal Research/Historically Black Colleges and Universities and Other Minority Institutions Conference
- 4th Annual Hydrogen Implementation Conference

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FOSSIL ENERGY

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Clean Coal & Natural Gas Power Systems

Carbon Sequestration

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- Ask Commercial Successes
- Fossil Energy Site Map

FOSSIL ENERGY NEWS SPOTLIGHT

Office of Fossil Energy Develops Educational Materials

Teaching students about fossil energy just got easier with the development of educational materials and classroom tools by the Department of Energy's Office of Fossil Energy. [Read more >](#)

DOE COAL, OIL & GAS NEWS

SPR to Continue Royalty-in-Kind FRI Program

The Department of Energy has issued a solicitation seeking contracts to exchange up to 13 million barrels of royalty oil from Federal leases in the Gulf of Mexico for crude oil that meets the specifications of the Strategic Petroleum Reserve. [Read more >](#)

DOE Technology Monitors CO₂ Injection in Australian Gas Field

Australia has launched the first carbon sequestration project in the southern hemisphere with the help of technology developed by researchers at the Department of Energy. The Oriskany Basin Pilot Project will inject and monitor carbon dioxide in a depleted gas field in southeastern Australia to demonstrate the feasibility of storing the greenhouse gas in the deeper formation of the Oriskany Basin. [Read more >](#)

Fossil Energy's Outreach Program Wins Excellence Award

FE's Office of Communications received the American Coal Council's 2007 Excellence in Development of Public Information: Print, Electronic or Broadcast Media Award, for its outreach efforts in educating the general public about coal and its place in the nation's energy supply. [Read more >](#)

OFFICE OF FOSSIL ENERGY

Ensuring that we can continue to rely on clean, affordable energy from our traditional fuel resources is the primary mission of DOE's Office of Fossil Energy. Fossil fuels supply 85% of the nation's energy, and we are working on such priority projects as pollution-free coal plants, more productive oil and gas fields, and the continuing readiness of federal emergency oil stockpiles.

Read more about:

- Fossil Energy Organization
- Business & Funding Opportunities
- Fossil Energy Employment Opportunities
- Upcoming Fossil Energy Events
- Topics/Opportunities for Students & Teachers

ENERGY POLICY ACT OF 2005

Learn how the Office of Fossil Energy is helping to implement the Act. [More >](#)

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