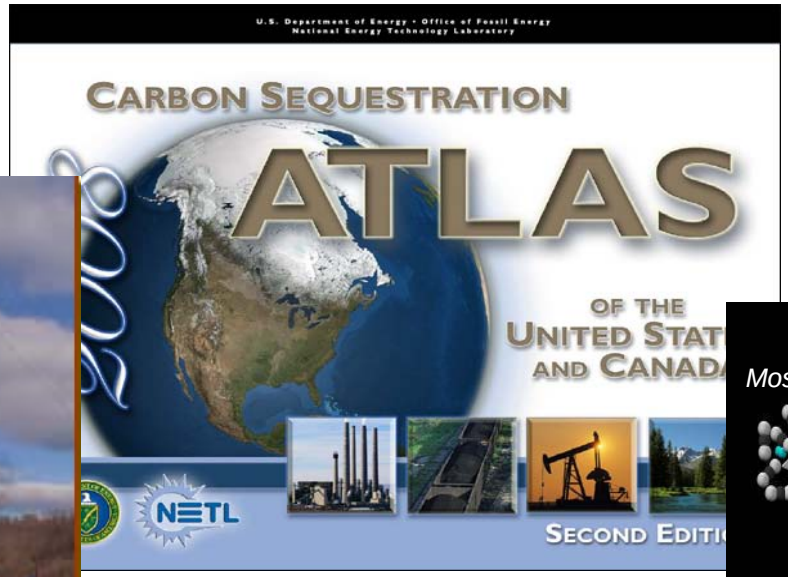
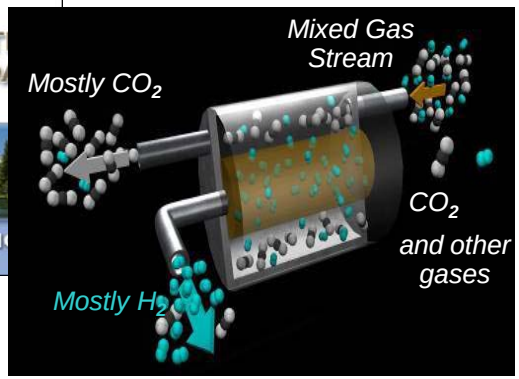
NATIONAL ENERGY TECHNOLOGY LABORATORY





Sequestration Program

Sean I. Plasynski, PhD
Sequestration Technology Manager
November 12, 2009

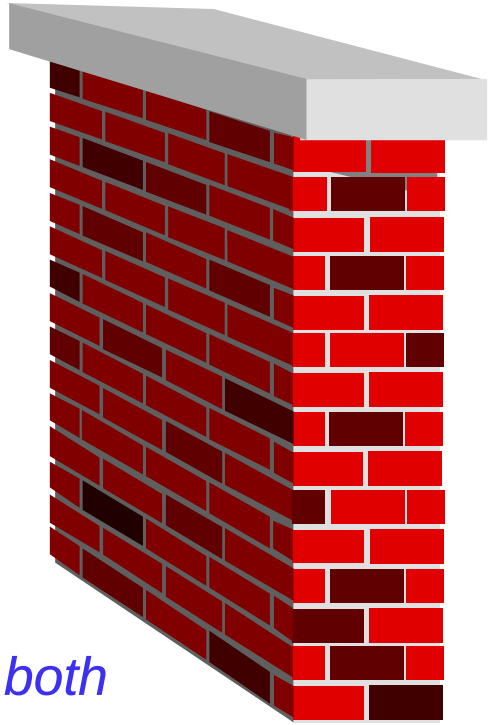
Key Challenges to Carbon Capture and Storage

Technical Issues

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

Legal/Social Issues

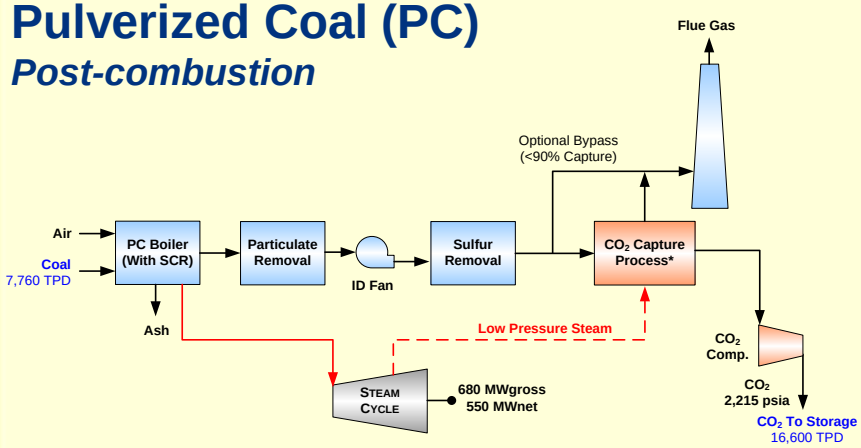
- **Regulatory Framework**
  - Permitting
  - Treatment of CO_2
- **Infrastructure**
- **Human Capital**
- **Legal Framework**
  - Liability
  - Ownership
    - pore space
    - CO_2
- **Public Acceptance (NIMBY → NUMBY)**



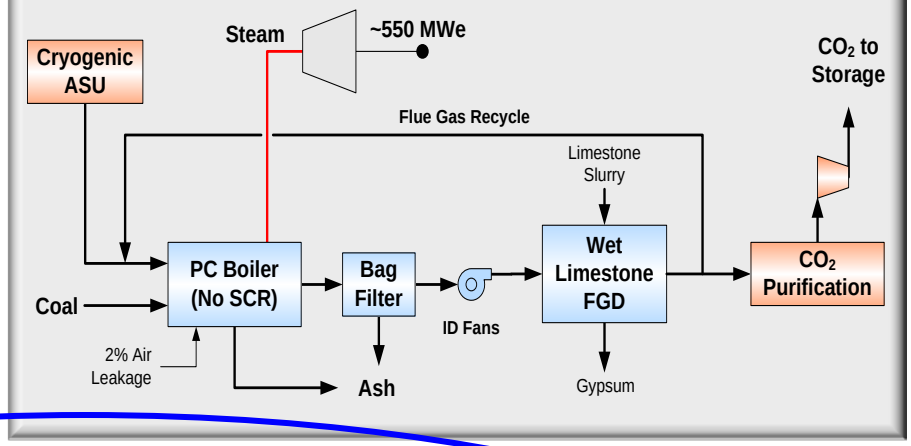
Projects helping to address both categories of issues

Fossil Energy CO_2 Capture Options

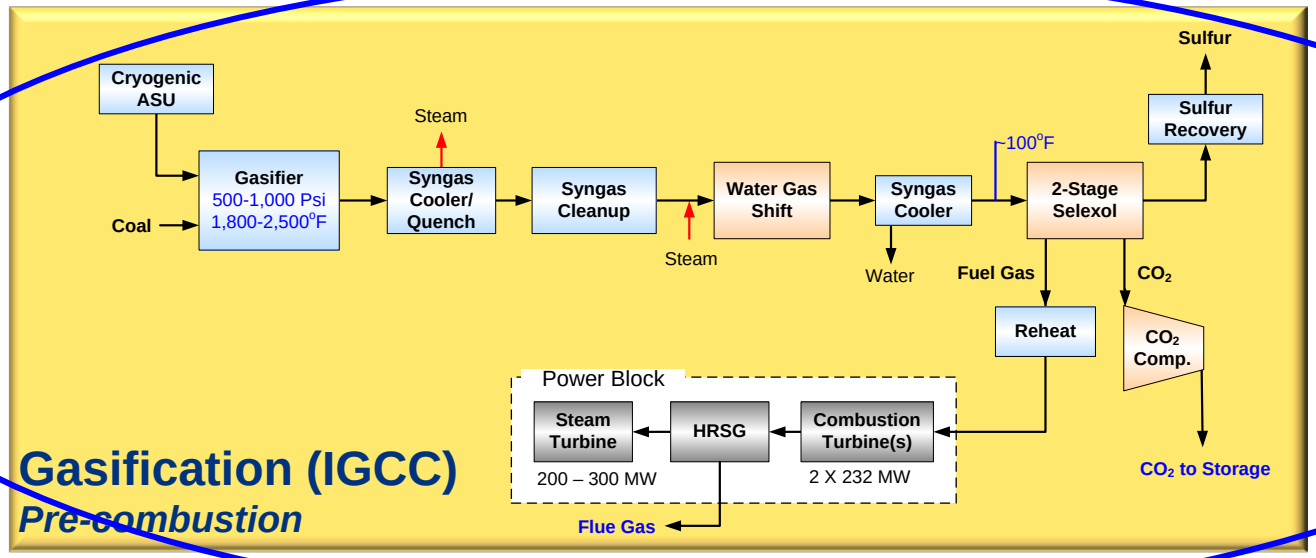
Pulverized Coal (PC)
Post-combustion



PC Oxy-combustion

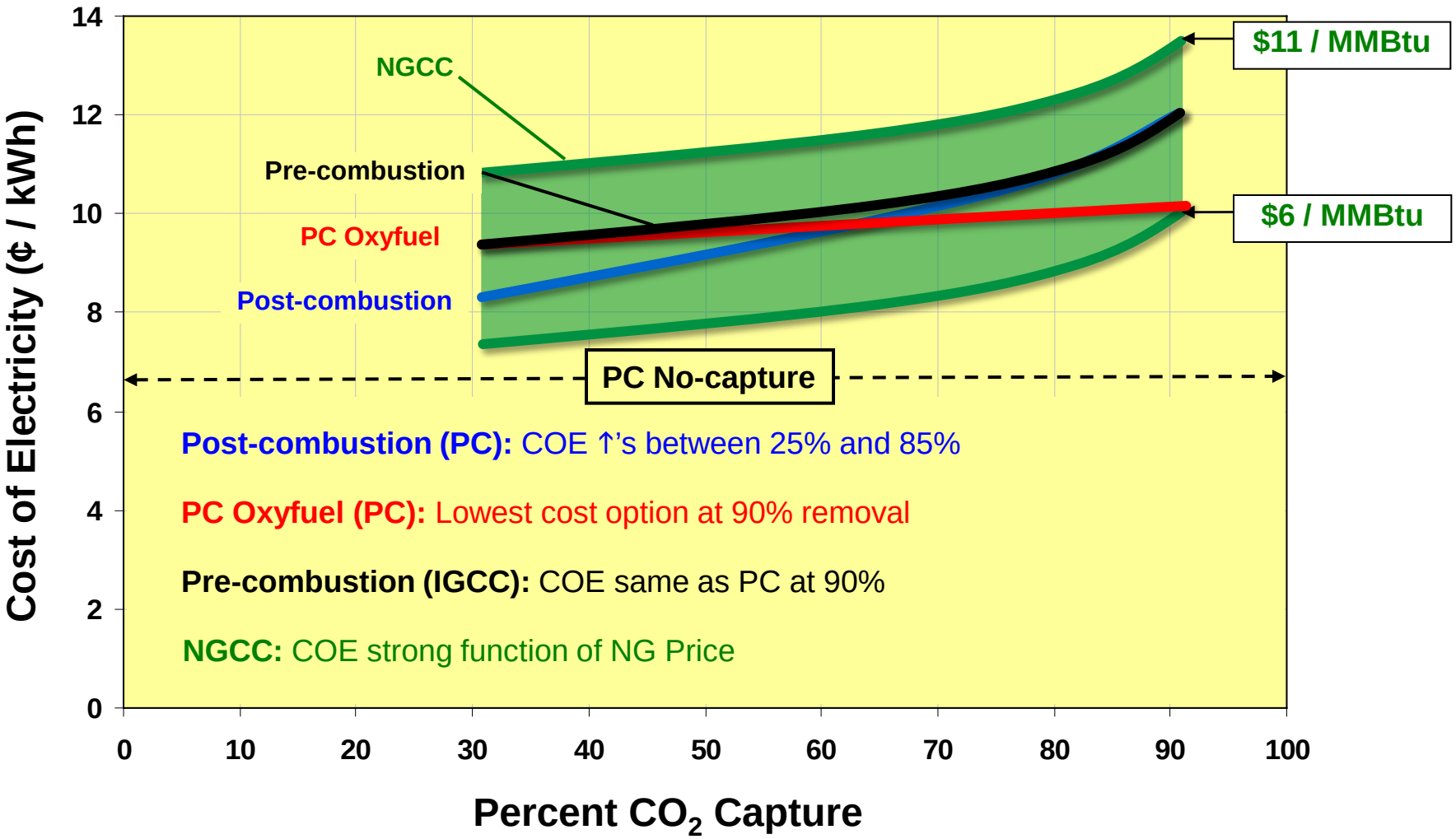


Gasification (IGCC)
Pre-combustion



Source: Cost and Performance Baseline for Fossil Energy Power Plants study, Volume 1: Bituminous Coal and Natural Gas to Electricity; NETL, May 2007.

CO_2 Capture Cost of Electricity Impact

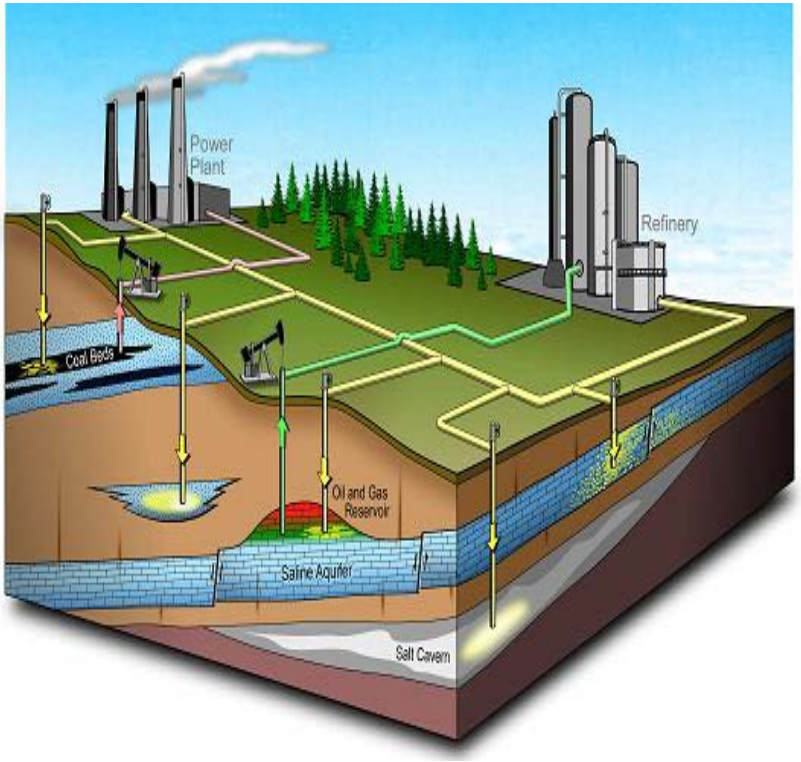


Cost and Performance Baseline for Fossil Energy Power Plants Study, Volume 1:
Bituminous Coal and Natural Gas to Electricity; NETL, May 2007.

Carbon Sequestration Program Goals

Develop Technology Options That...

- **Deliver technologies & best practices that provide Carbon Capture and <u>Safe</u> Storage (CCSS) with:**
  - 90% CO_2 capture at source
  - 99% storage permanence
  - < 10% increase in COE
    - Pre-combustion capture (IGCC)
  - < 35% increase in COE
    - Post-combustion capture
    - Oxy-combustion



U.S. DEPARTMENT OF ENERGY • OFFICE OF FOSSIL ENERGY
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CARBON SEQUESTRATION PROGRAM

Core R&D

- Capture
- Geologic Storage
- Monitoring, Verification, and Accounting (MVA)
- Simulation and Risk Assessment
- CO_2 Use/Reuse

Benefits

- Reduced cost of CCS
- Tool development for risk assessment and mitigation
- Accuracy/monitoring quantified
- Capacity validation
- Indirect storage

Technology Solutions

Infrastructure

Regional Carbon Sequestration Partnerships

- Characterization
- Validation
- Development

Other Large-Scale Projects

Benefits

- Human capital
- Stakeholder networking
- Regulatory policy development
- Visualization knowledge center
- Best practices
- Public outreach and education

Technology Solutions

Lessons Learned

Lessons Learned

Global Collaborations

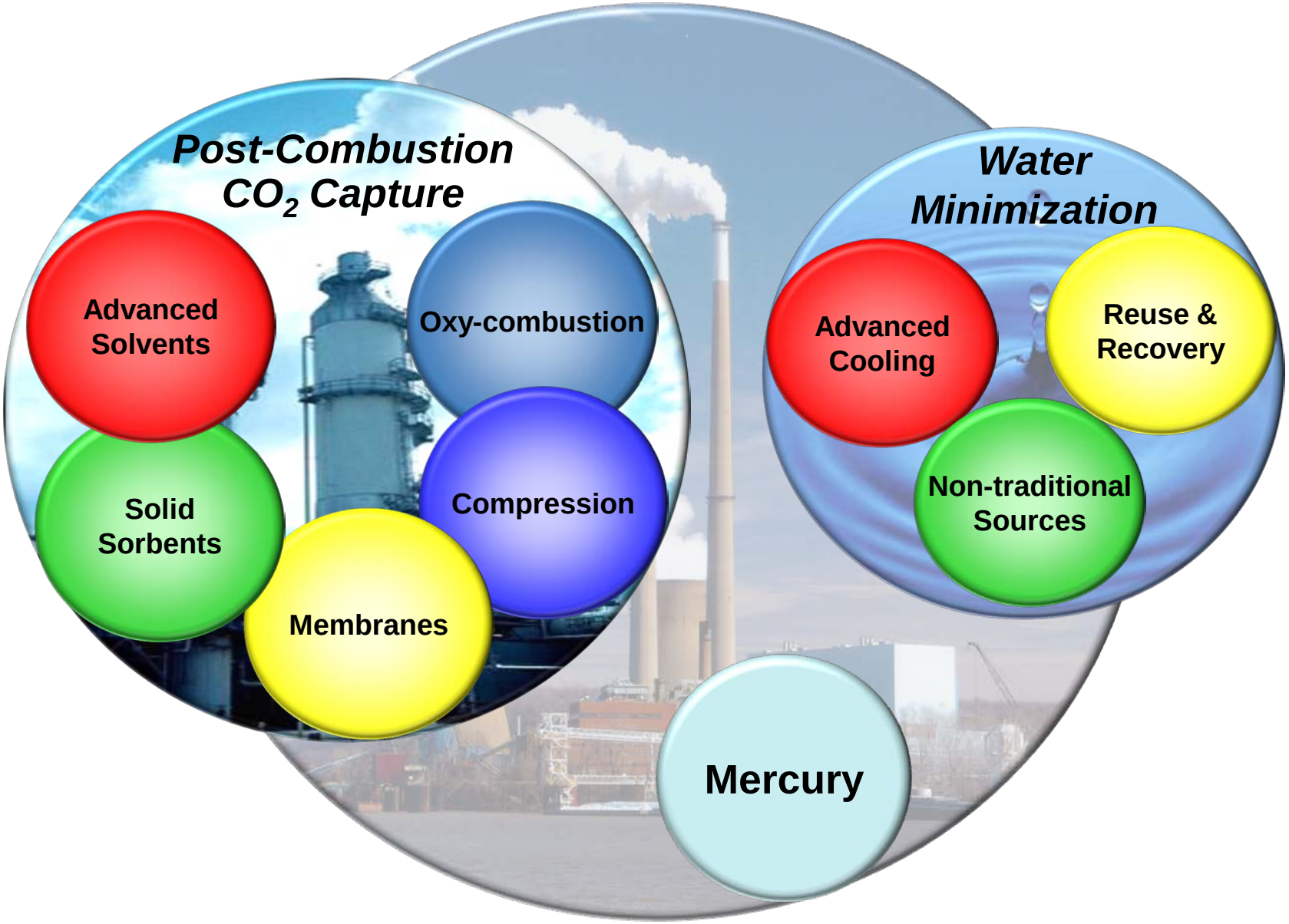
- North America Energy Working Group
- Carbon Sequestration Leadership Forum
- International Demonstration Projects
- Asian-Pacific Partnership (APP)

Benefits

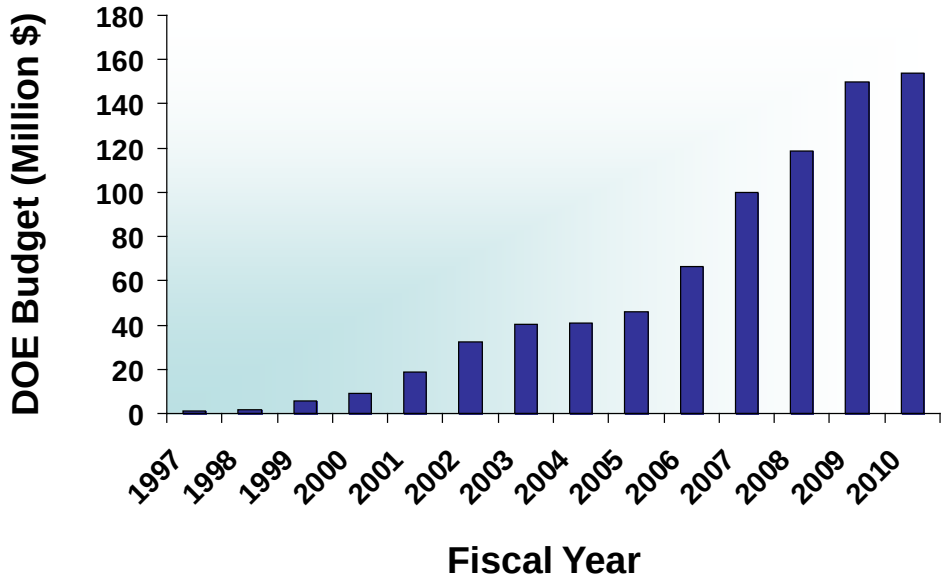
- Knowledge building
- Project development
- Collaborative international knowledge
- Capacity/model validation
- CCS commercial deployment

Demonstration and Commercialization Carbon Capture and Sequestration (CCS)

Existing Plants Program Structure



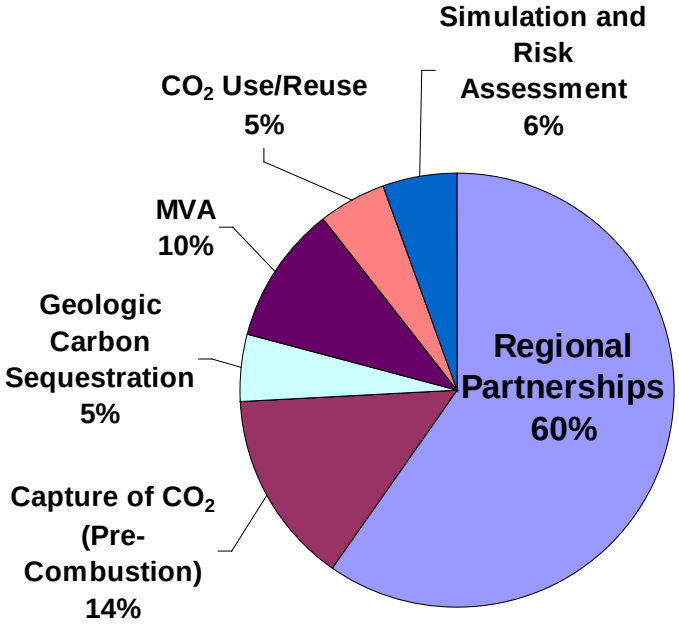
Sequestration Program Statistics FY2009



Strong industry support
~ 39% cost share on projects

Federal Investment to Date
~ $631 Million

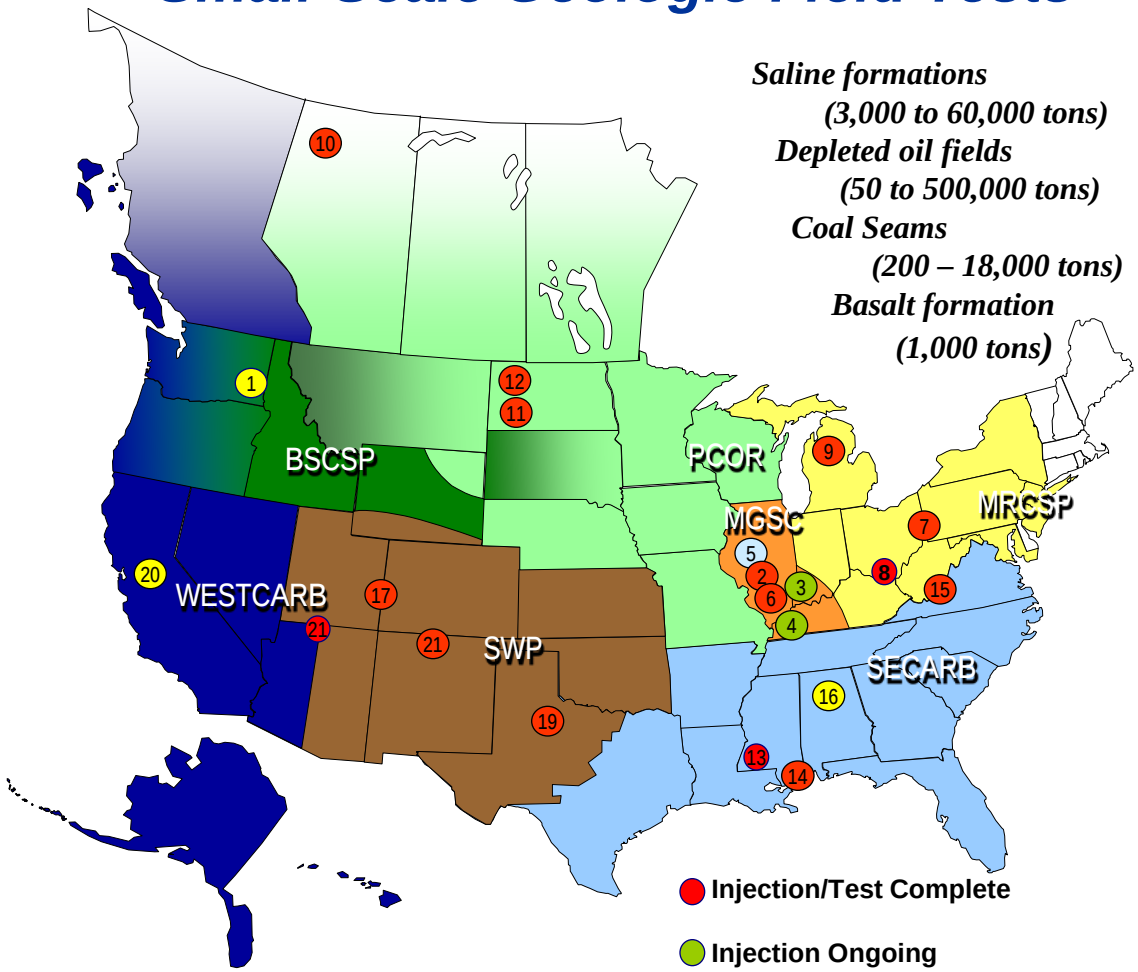
2009 Carbon Sequestration Program Budget Breakdown



Diverse research portfolio

~ 80-100 Active R&D Projects

RCSP Validation Phase: *Phase II*
Small-Scale Geologic Field Tests



Saline formations
(3,000 to 60,000 tons)
Depleted oil fields
(50 to 500,000 tons)
Coal Seams
(200 – 18,000 tons)
Basalt formation
(1,000 tons)

- Injection/Test Complete
- Injection Ongoing
- 2009/early 2010 Injection
- Project moved to Phase III (Injection 2010/2011)

Completed 15 Injections

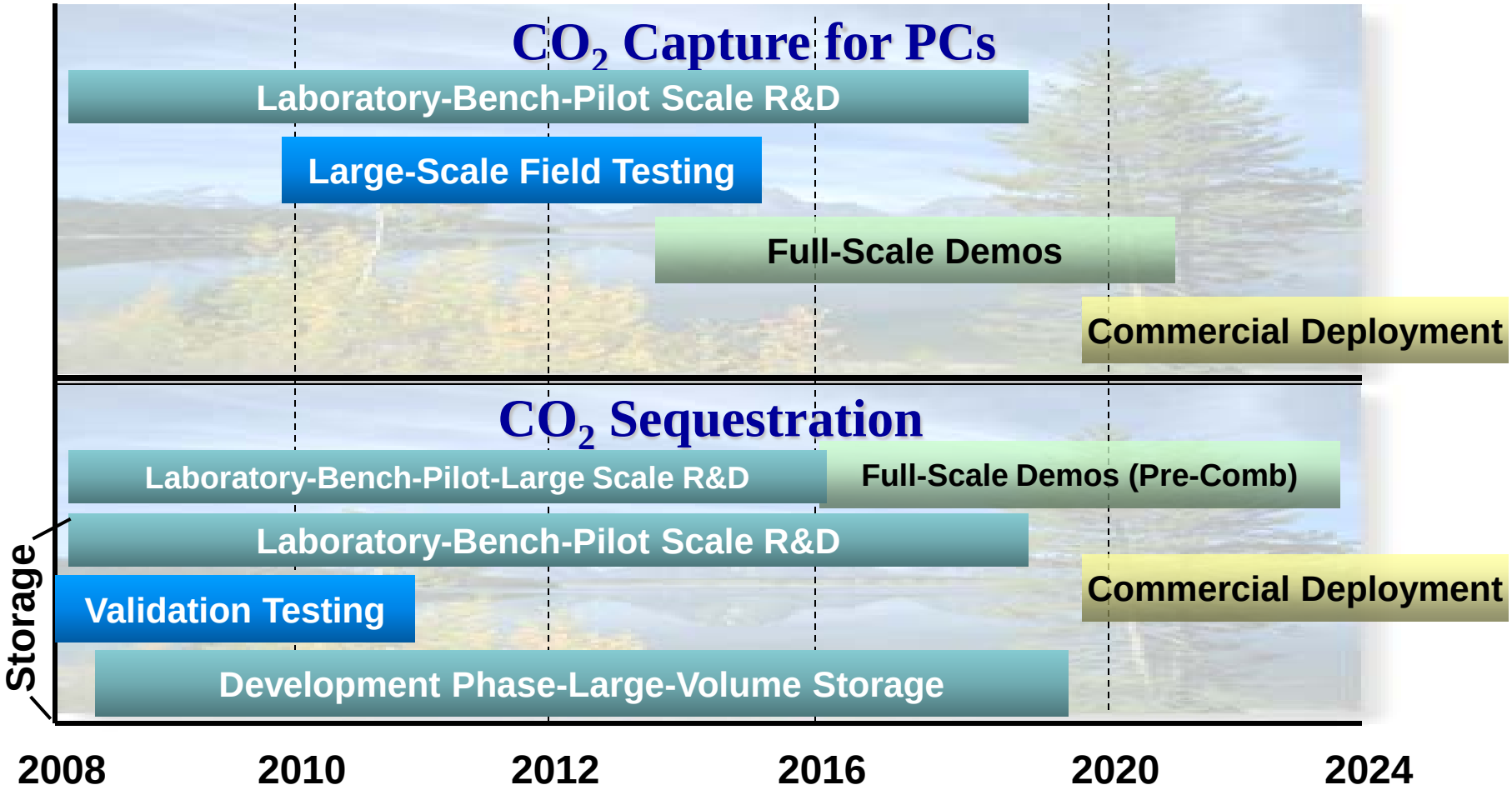
Over 1.35 M Tons injected

RCSP	Formation Type	Geologic Province
Big Sky	Saline 1	Columbia Basin
MGSC	Oil-bearing 2 3 4 Saline 5 Coal seam 6	Illinois Basin
MRCSP	Saline 7 8 9	Cincinnati Arch, Michigan Basin, Appalachian Basin
PCOR	Oil-bearing 10 11 Coal seam 12	Keg River, Duperow, Williston Basin
SECARB	Oil-bearing 13 Saline 14 Coal seam 15 16	Gulf Coast, Mississippi Salt Basin, Central Appalachian, Black Warrior Basin
SWP	Oil-bearing 17 18 Coal seam 19	Paradox Basin, Aneth Field, Permian Basin, San Juan Basin
WESTCARB	Saline 20 21	Sacramento Valley, Colorado Plateau

Data Current as of April 2009

RD&D Timeline to Commercial Deployment

CO_2 Capture for PCs and Sequestration Efforts



EPRI, Assessment of Post-Combustion Capture Technology Developments, 2007; Gottlicher (2004)

Pre-Combustion Carbon Capture Technologies for Coal-Based Gasification Plants

Funding Opportunity Announcement (FOA): DE-PS26-08NT00699

Topic Area 1

DE-PS26-08NT00699-1: High-Temperature, High-Pressure Membranes

Topic Area 2

DE-PS26-08NT00699-2: High-Efficiency Solvents

Topic Area 3

DE-PS26-08NT00699-3: Solid Sorbents with Commercially-Relevant Separation Capacity and Regenerable

Topic Area 4

DE-PS26-08NT00699-4: Advanced separation devices for separating CO_2 or H_2 from shifted syngas and novel approaches for pre-combustion removal and capture of the carbon content of fuels

Pre-combustion CO_2 Capture
Kick-off Meetings
November 12 and 13, 2009
Pittsburgh
922A

November 12, 2009

8:30 to 8:45 Sean Plasynski
Welcome/Sequestration Program Overview

8:45 to 10:05 University Of Minnesota
Hydrogen Selective Ex-foliated Zeolite Membranes

10:05 to 10:20 Break

10:20 to 11:40 Pall Corporation
Designing and Validating Ternary Pd Alloys for Optimum Sulfur/Carbon Resistance in Hydrogen Separation and Carbon Capture Membrane Systems Using High-Throughput Combinatorial Methods

11:40 to 12:15 Lunch

12:15 to 1:35 Arizona State University
Pre-Combustion Carbon Dioxide Capture by a New Dual-Phase Ceramic-Carbonate Membrane Reactor

High-Temperature High-Pressure Membrane

1:35 to 2:55 SRI International
CO_2 Capture from IGCC Gas Streams Using the AC-ABC Process

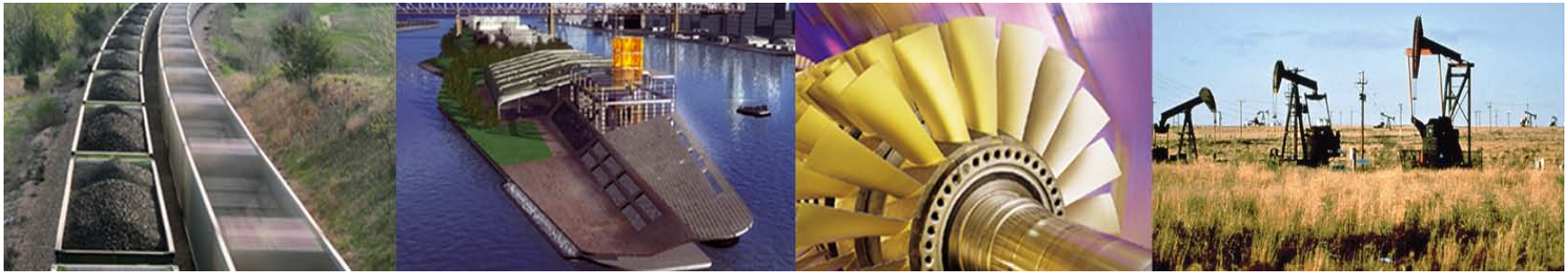
2:55 to 3:10 Break

High-Efficiency Solvents

3:10 to 4:30 TDA Research, Inc.
A Low-Cost, High-Efficiency Regenerable Sorbent for Pre-Combustion CO_2 Capture

Solid Sorbents

November 13, 2009

8:30 to 9:50	URS Group Evaluation of Dry Sorbent Technology for Pre-Combustion CO_2 Capture	Solid Sorbents
9:50 to 10:10	Break	
10:10 to 11:30	Gas Technology Institute Pre-Combustion Carbon Capture by a Nanoporous, Superhydrophobic Membrane Contactor Process	Advanced Separation devices
11:30 to 12:00	Lunch	
12:00 to 1:20	Membrane Technology Research, Inc. Novel Polymer Membrane Process for Pre-Combustion CO_2 Capture from Coal-Fired Syngas	
1:20 to 2:40	New Jersey Institute of Technology Pressure Swing Absorption Device	
2:40	Adjourn	

Questions ?