



# **U.S. Department of Energy Carbon Sequestration Initiatives**

**June 24, 2010**

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Program Manager



# Outline

- **DOE Carbon Sequestration Program**
- **American Recovery and Reinvestment Act of 2009 (ARRA) – Fossil Energy Research & Development**
- **Other CCS Activities**
  - International Cooperation
  - Interagency Task Force on Carbon Capture and Storage
  - Geologic Storage Regulatory Framework

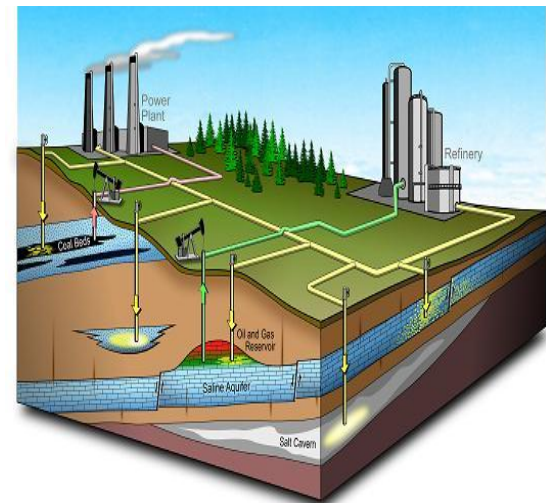


# CCS R&D Mission & Approach

Critically Linked to Climate & Security Goals

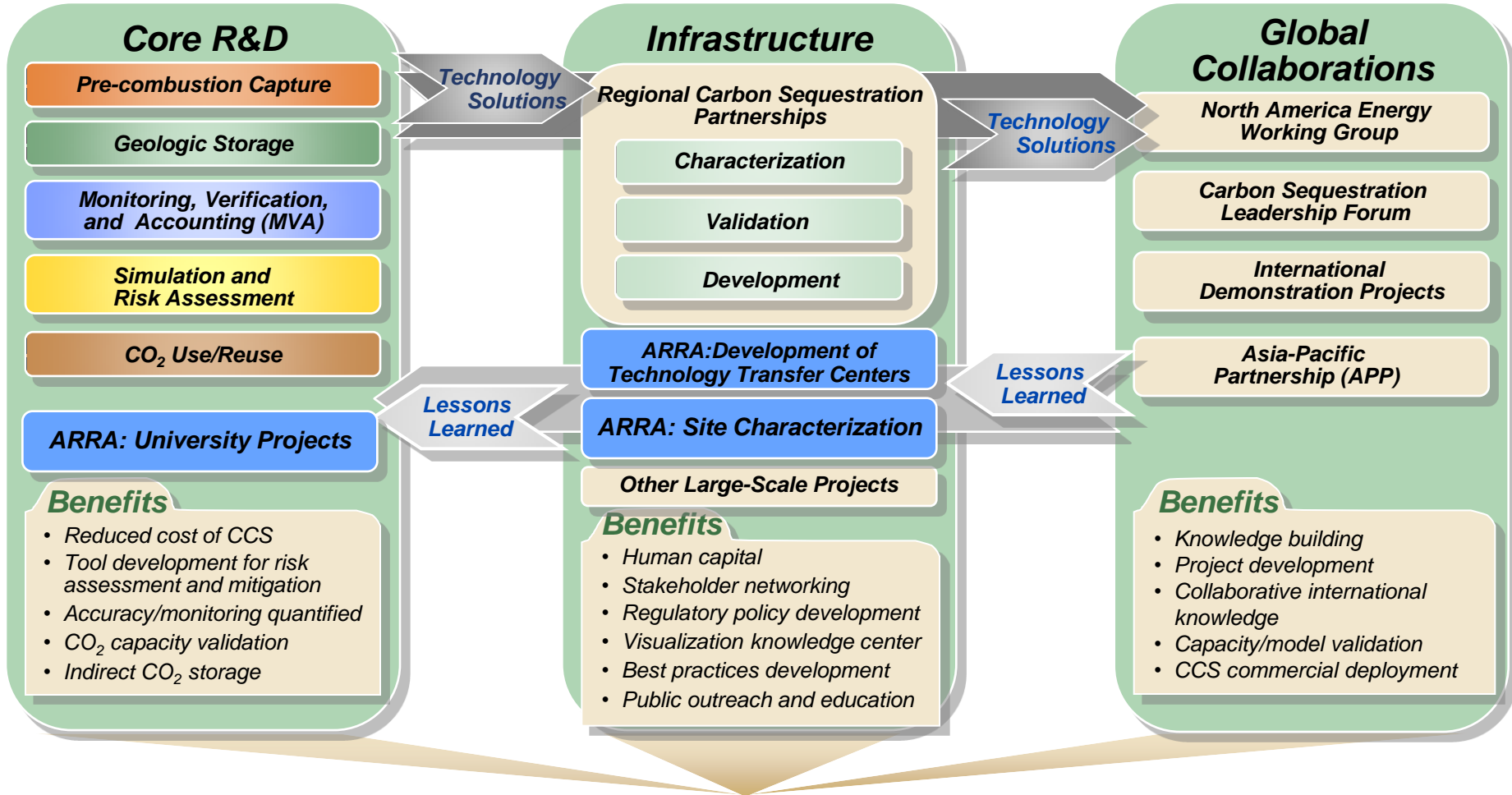
## Develop Technologies and Best Practices That Facilitates Wide Scale Deployment of Fossil Fuel Energy Systems Integrated With CCS by 2020

- Develop plant designs & components optimized for CCS
- Reduce capture costs
  - <10% increase in COE (pre-combustion)
  - <35% increase in COE (post- and oxy-combustion)
- Validate storage capacity
- Validate storage permanence
- Create private/public partnerships
- Promote infrastructure development
- Put “first of kind” field projects in place
- Develop tools, protocols & best practices



**U.S. DEPARTMENT OF ENERGY • OFFICE OF FOSSIL ENERGY  
NATIONAL ENERGY TECHNOLOGY LABORATORY**

# CARBON SEQUESTRATION PROGRAM *with ARRA Projects*

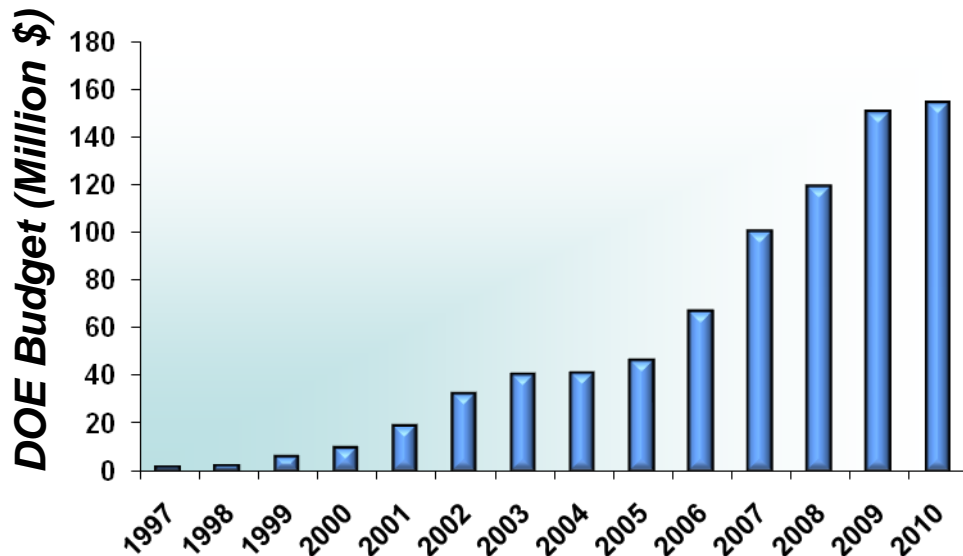


**Demonstration and Commercialization Carbon Capture and Storage (CCS)**



# Sequestration Program Total Funding

## Program Statistics 2009



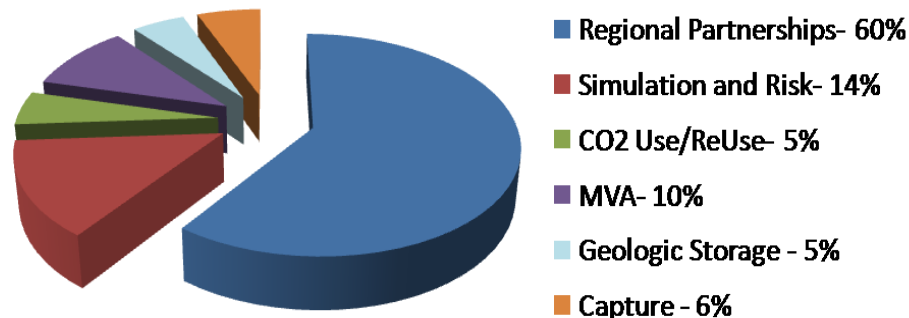
*Diverse Research Portfolio*  
~ 80-100 Active R&D Projects

*Strong industry support*  
~ 39% cost share on projects

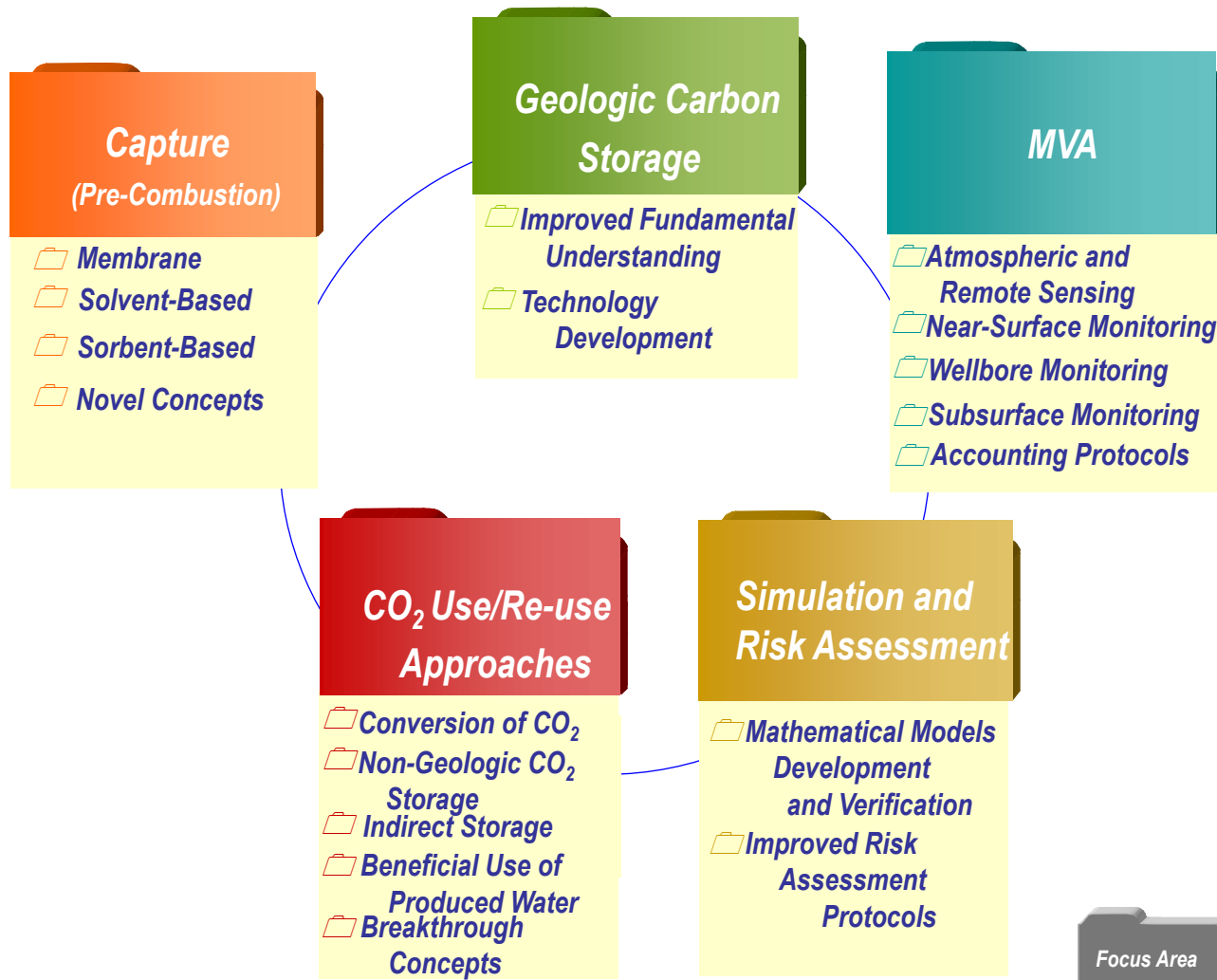
*Federal Investment to Date*  
~ \$785 Million

### 2009 Program Budget Breakdown

**NOTE: Innovations for Existing Plants (IEP) Program provides an additional \$50 million for post-combustion and oxycombustion capture**

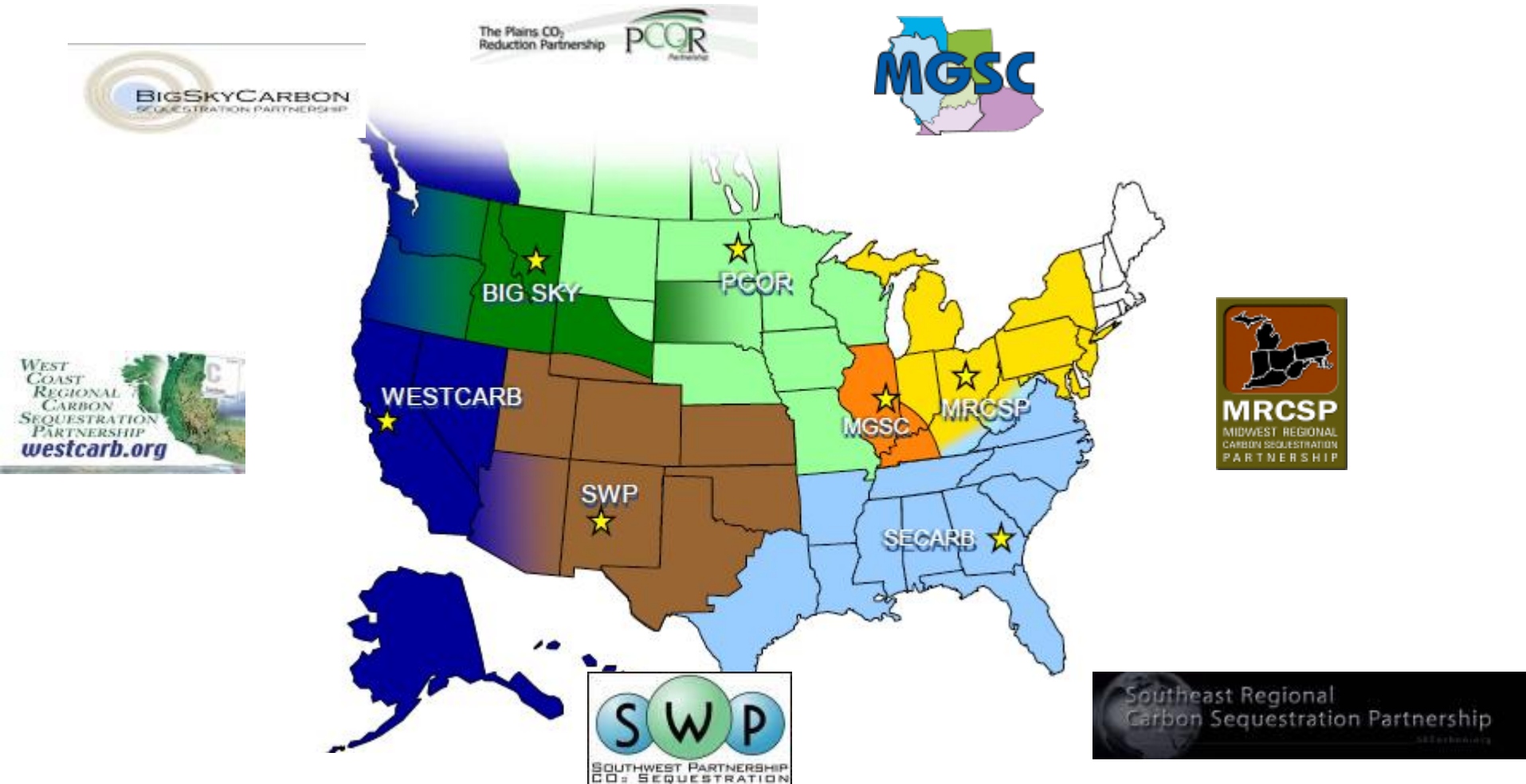


# Core R&D Focus Areas and Supporting Research Pathways

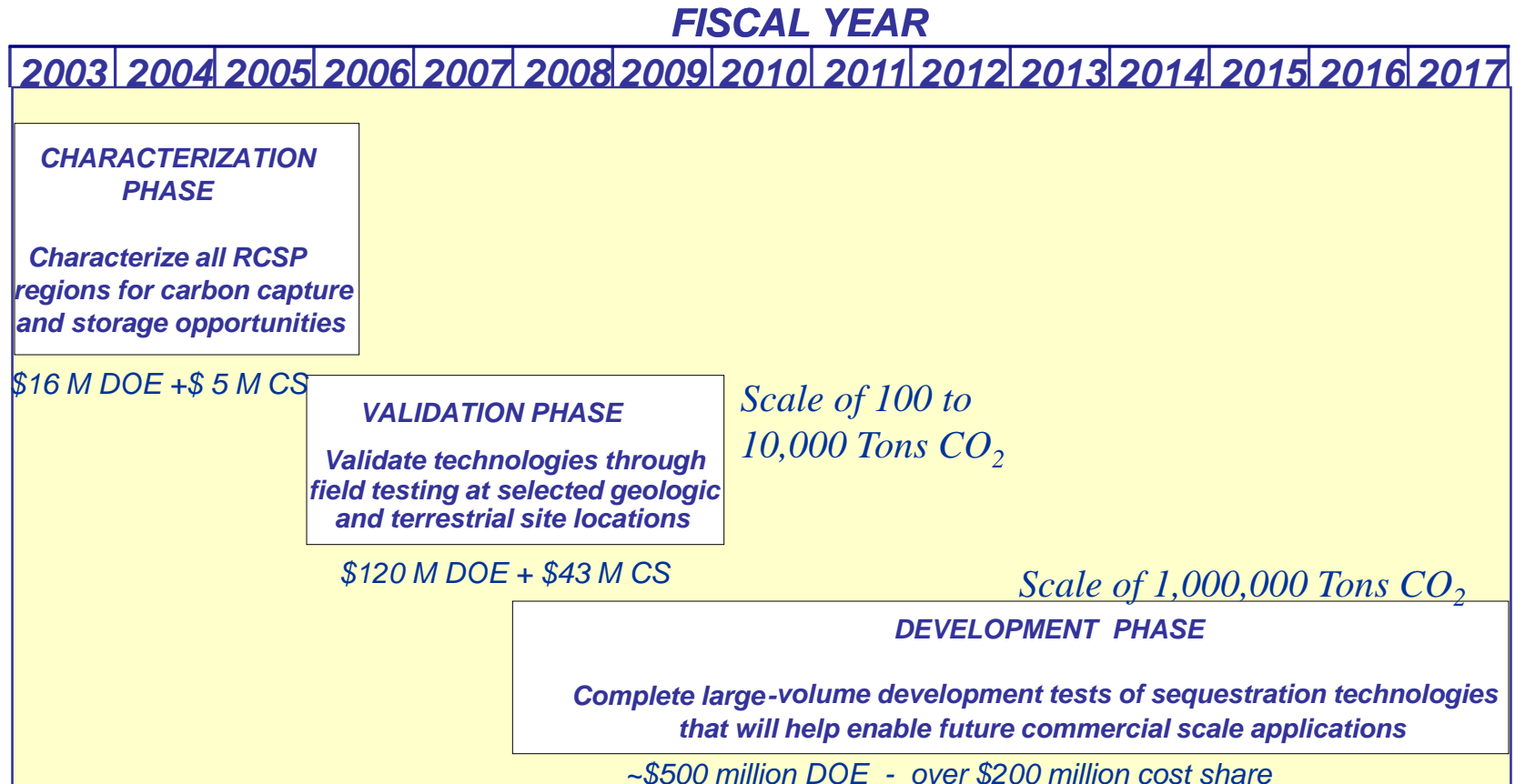


# Regional Carbon Sequestration Partnerships

## *“Developing the Infrastructure for Wide Scale Deployment”*



# Regional Carbon Sequestration Partnerships Program Phases

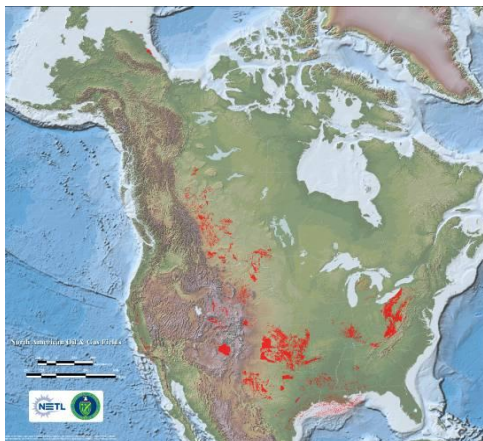




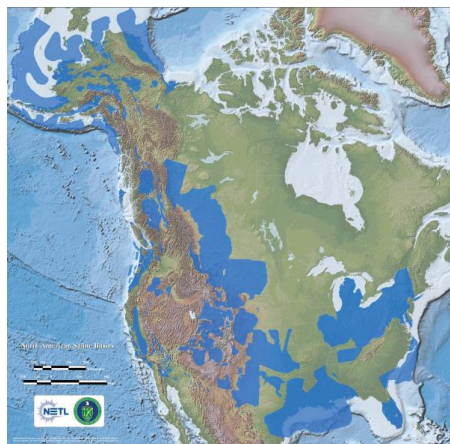
# National Atlas Highlights (Atlas II)

## Adequate Storage Projected

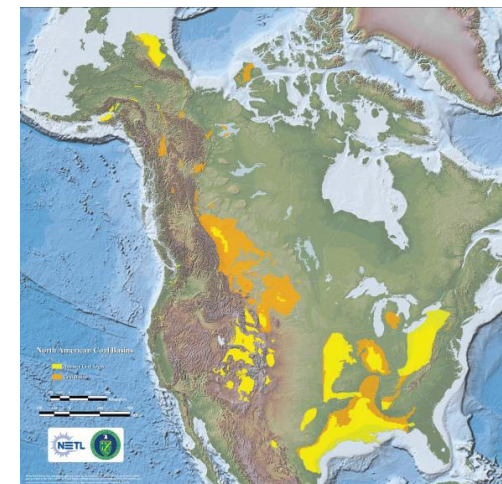
U.S. Emissions ~ 6 GT CO<sub>2</sub>/yr all sources



**Oil and Gas Fields**



**Saline Formations**



**Unmineable Coal Seams**

*North American CO<sub>2</sub> Storage Potential  
(Giga Tons)*

**Conservative  
Resource  
Assessment**

Sink Type	Low	High
Saline Formations	3300	13000
Unmineable Coal Seams	160	180
Oil and Gas Fields	140	140

**Hundreds of  
Years of  
Storage  
Potential**

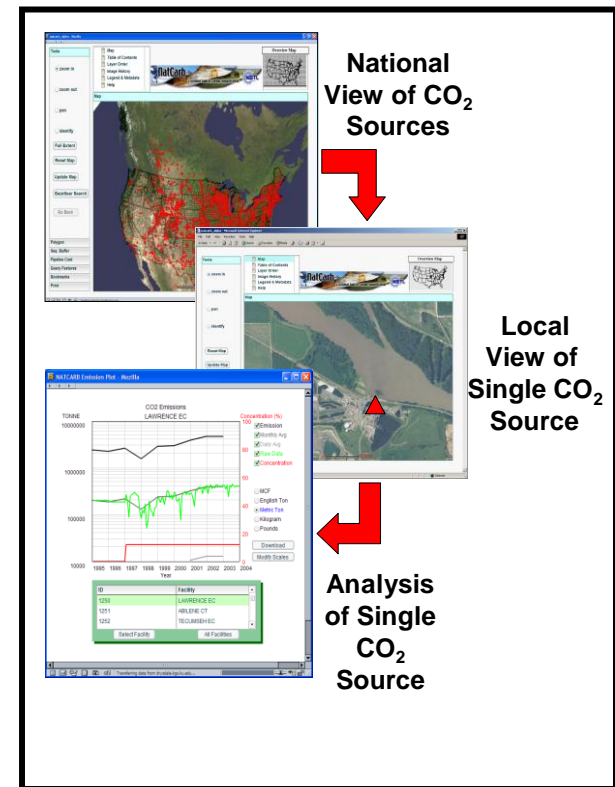


# National Carbon Sequestration Database and Geographical Information System (NATCARB)



- Available “Free-Of-Charge” on Internet
- Portal to Key Source & Sink Databases
- Decision Support Tools
- Outreach tool
  - Website gets 600+ unique visitors every month from around the world

[www.natcarb.org](http://www.natcarb.org)

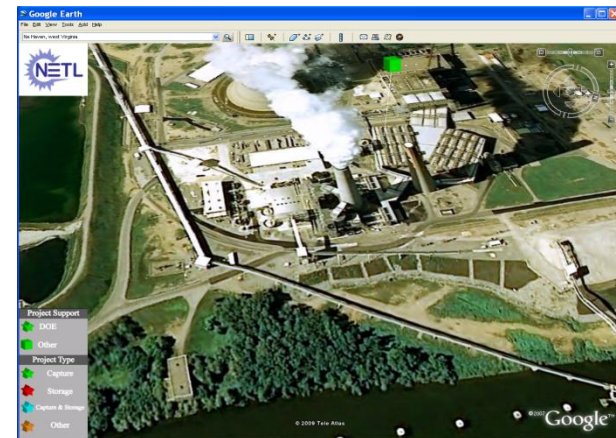
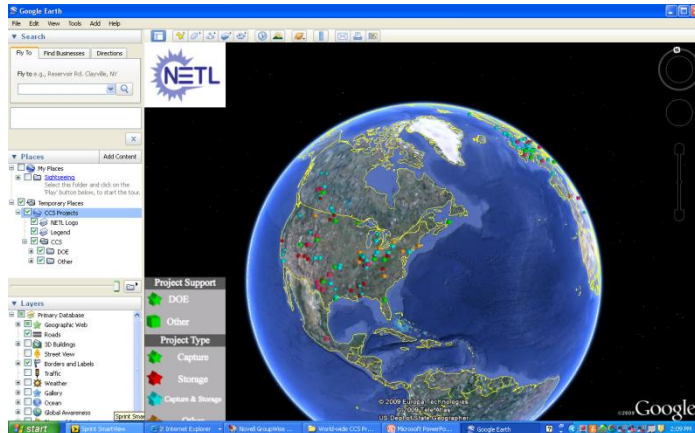


CO<sub>2</sub> Sources



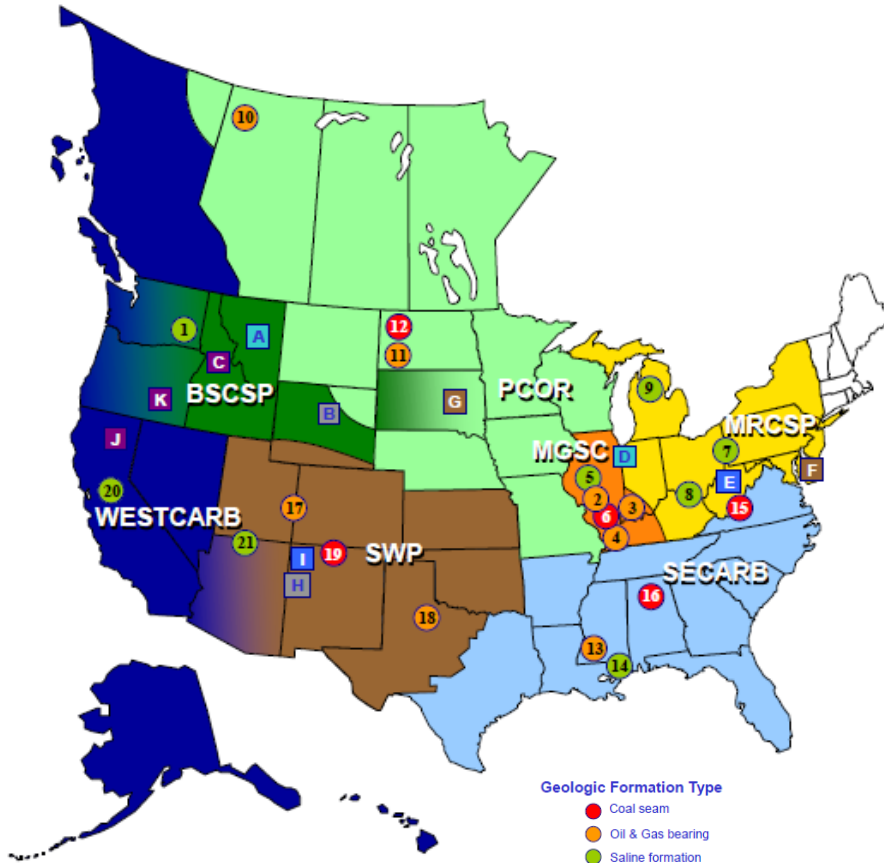
# World-Wide CCS Projects Database

- **Data compiled from a multitude of sources**
  - Websites, factsheets, reports, news postings, etc...
- **To date, ~195 projects projects**
  - Includes active, developing, proposed, on hold, or completed)
  - USA: ~ 80 projects
  - International: ~ 115 projects
- **Approximately 125 projects active**
  - Either capturing, injecting, developing infrastructure, site characterization/selection, designing, or in the permitting process.
    - USA Projects: ~ 50 projects
    - International Projects: ~ 75 projects



# RCSP Phase II: Validation Phase

## Small-Scale Geologic and Terrestrial Tests

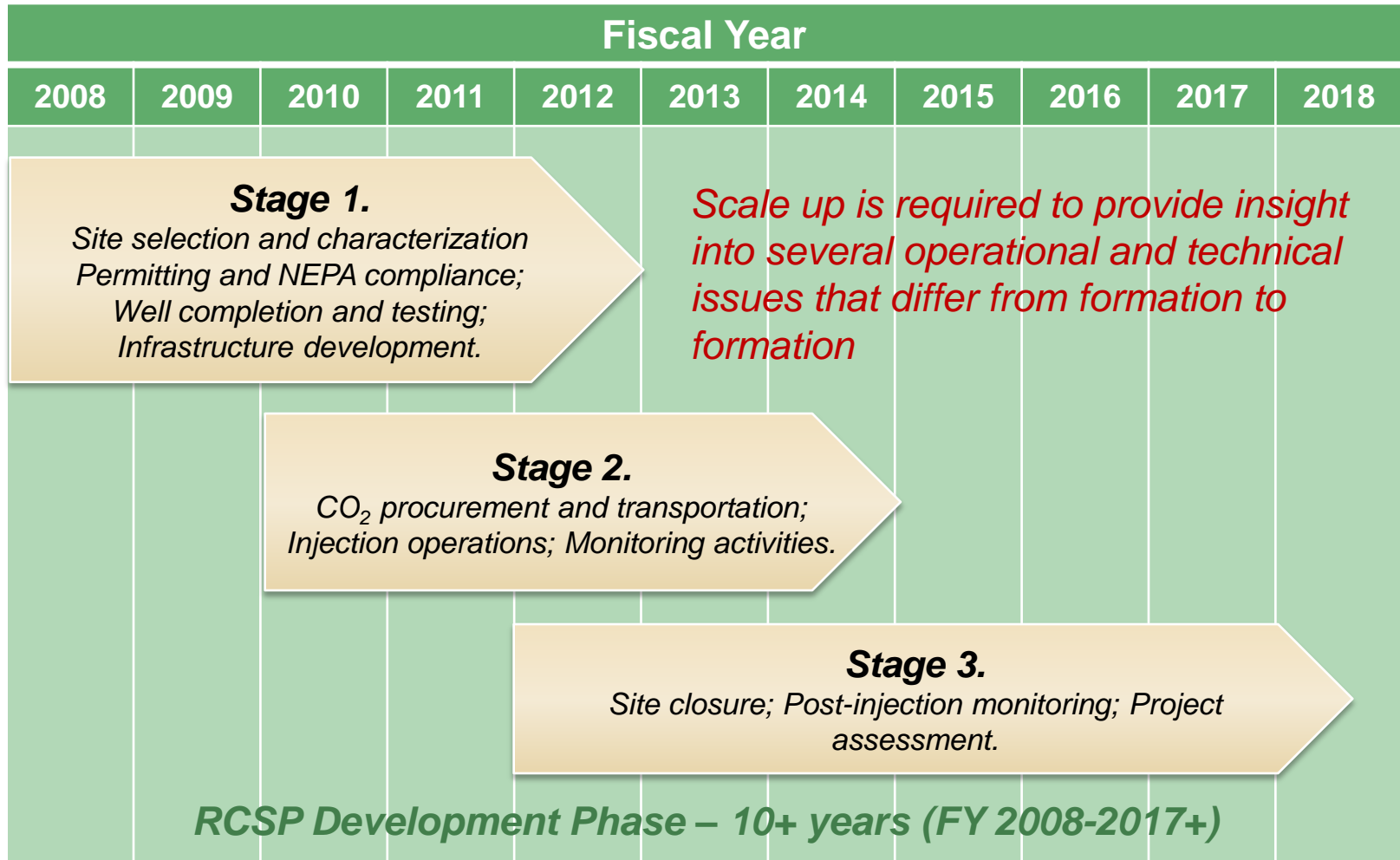


Partnership	Geologic Province/ Location	Geologic		Terrestrial
		Total CO <sub>2</sub> Injection (tons CO <sub>2</sub> )	Approximate Depth (feet)	Estimated CO <sub>2</sub> Capacity
1	Columbia Basin	0*	2,500 – 4,000	
A B C <b>BIG SKY CARBON SEQUESTRATION PARTNERSHIP</b>	North Central MT Eastern WY Region-wide			60 Mt over 20 years 30 Mt over 10 years 640 – 1,040 Mt over 80 years
2 3 4 5 6 <b>MGSC</b>	Loudon Oil Field Mumford Hills Oil Field Sugar Creek Oil Field Illinois Basin Illinois Basin	< 50 2,700* 4,600* 0* 100	1,550 1,551 1,548 6,650 – 7,050 1,000	
7 8 9 D E F <b>MRCSP MIDWEST REGIONAL CARBON SEQUESTRATION PARTNERSHIP</b>	Appalachian Basin Cincinnati Arch Michigan Basin Region-wide Region-wide Cambridge, MD	< 100 1,000 60,000	5,900 – 8,300 3,200 – 3,500 3,200 – 3,500	25 Mt over 20 years 100 Mt over 20 years TBD
10 11 12 G <b>The Plains CO<sub>2</sub> Reduction Partnership PCOR</b>	Keg River Formation Duperow Formation Williston Basin Great Plains wetlands complex (PPR)	30,000 440 90	5,000 10,000 – 10,500 1,600 – 1,800	14.4 Mt
13 14 15 16 <b>SECARB</b>	Gulf Coast } stacked Gulf Coast } Mississippi Coastal Plain Central Appalachian Black Warrior Basin	500,000 3,082 1,000 0*	10,304 10,400 8,600 1,600 – 2,300 1,500 – 2,500	
17 18 19 H I <b>SWP SOUTHWEST PARTNERSHIP CO<sub>2</sub> SEQUESTRATION</b>	Paradox Basin–Aneth Field Permian Basin San Juan Basin Region-wide San Juan Basin Coal Fairway (Navajo City, NM)	250,000 475,000 18,430	5,600 – 5,800 5,800 3,000	TBD TBD
20 21 J K <b>WEST COAST REGIONAL CARBON SEQUESTRATION PARTNERSHIP westcarb.org</b>	Sacramento Basin* Colorado Plateau Shasta County, CA Lake County, OR	0* 0	8,000 4,000	4,600 Mt over 80 years (CA) 900 Mt over 80 years (OR)

\* Currently injecting or will begin injecting in 2010

# RCSP Phase III: Development Phase

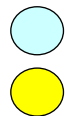
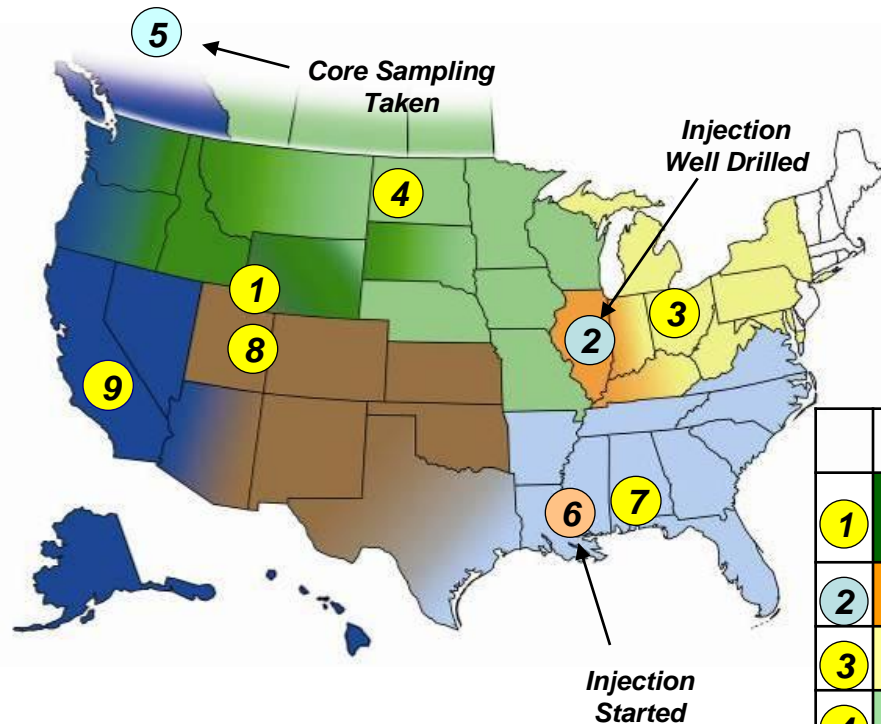
## Scaling Up Towards Commercialization



# RCSP Phase III: Development Phase

## Large-Scale Geologic Tests

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



**2010/2011 Injection Scheduled**

**Scheduled**

**2011/2012 Injection Scheduled**

**Scheduled**

	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

# CCS Best Practice Manuals

Critical Requirement For Significant Wide Scale Deployment

Capturing Lessons Learned

<b>Best Practice Manual</b>	<b>Version 1 (Phase II)</b>	<b>Version 2 (Phase III)</b>	<b>Final Guidelines (Post Injection)</b>
<b>Monitoring Verification and Accounting</b>	2009	2017	2020
<b>Site Characterization</b>	2010	2016	2020
<b>Simulation and Risk Assessment</b>	2010	2017	2020
<b>Well Construction and Closure</b>	2010	2017	2020
<b>Regulatory Compliance</b>	2010	2016	2020
<b>Public Education</b>	2009	2016	2020
<b>Terrestrial Sequestration Practices</b>	2010	2016 – Post MVA Phase III	



# Introduction to American Recovery and Reinvestment Act (ARRA) – Sequestration Activities





# The American Recovery and Reinvestment Act of 2009 (ARRA)

- **Provides an Additional \$3.4 Billion for Fossil Energy Research and Development to:**
  - Develop and Demonstrate CCS Technology in Partnership with Industry to Reduce GHG Emissions
  - To Transition this Technology to Industry for their Deployment and Commercialization
  - Become the World's Leader in Science and Technology
  - Implement Projects to Support Economic Recovery



# American Recovery and Reinvestment Act of 2009 (ARRA) – Fossil Energy CCS

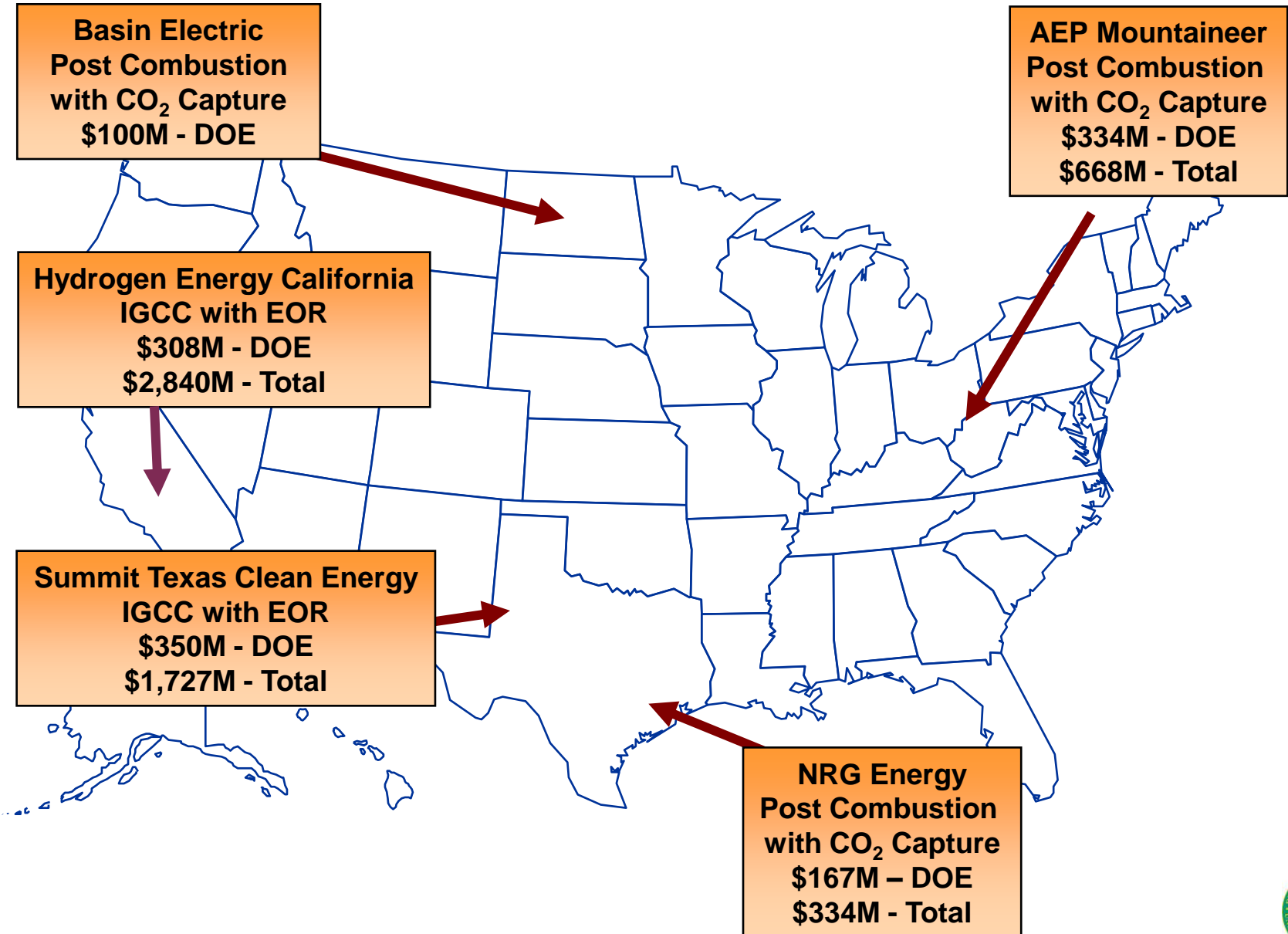
<b>Fossil Energy (\$ in Thousands)</b>	<b>Funding Amount</b>
<b>Clean Coal Power Initiative – Round 3 FOA</b>	<b>\$ 800,000</b>
<b>Industrial Carbon Capture Solicitation</b>	<b>\$1,520,000</b>
<b>Geologic Formation Site Characterization</b>	<b>\$50,000</b>
<b>Geologic Sequestration Training &amp; Research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



# CCPI Round 3



# Current CCPI Round 3 Projects



# Industrial Carbon Capture & Storage (ICCS)



# Industrial CCS Projects

## Area 1: large-scale CCS from industrial sources

- Objectives
  - Demonstrate advanced CCS technologies
  - To progress beyond the R&D stage of readiness
  - Integration with comprehensive Monitoring, Verification & Accounting (MVA)
  - 1MM tons/yr of CO<sub>2</sub> emissions from each plant for CCS

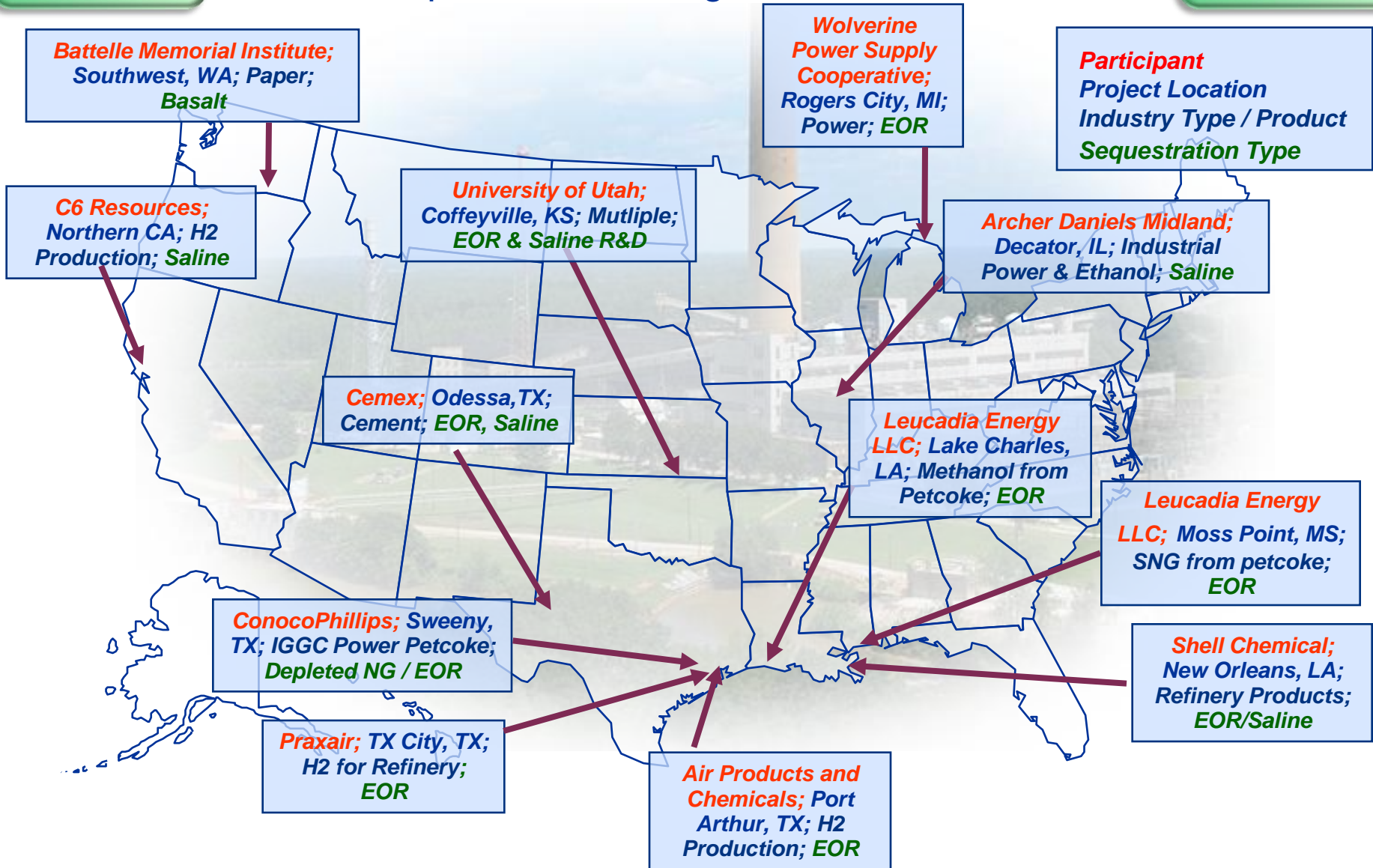
## Area 2: Innovative Concepts for Beneficial CO<sub>2</sub> Reuse

- Objectives
  - Carry out testing of beneficial CO<sub>2</sub> use technologies and processes that will provide information on **cost and feasibility** of implementation and operation
  - Projects must be **beyond R&D stage** and are ready for implementation at **pilot-scale level**



# Project Locations for Area 1, Phase 1

## Carbon Capture and Storage from Industrial Sources



# Project Locations for Area 1, Phase 2

## Carbon Capture and Storage from Industrial Sources



*Archer Daniels Midland,  
Decatur, IL  
Industrial Power & Ethanol  
Mt. Simon Sandstone  
Reservoir (Saline)*

*Air Products, Port Arthur, TX  
Steam Methane Reformer H<sub>2</sub>  
Production  
Sequestering into Denbury's  
Pipeline for EOR*

*Leucadia Energy, Lake Charles, LA  
Methanol from Petcoke  
EOR in Hastings and Oyster Bayou Oil  
Fields, TX*

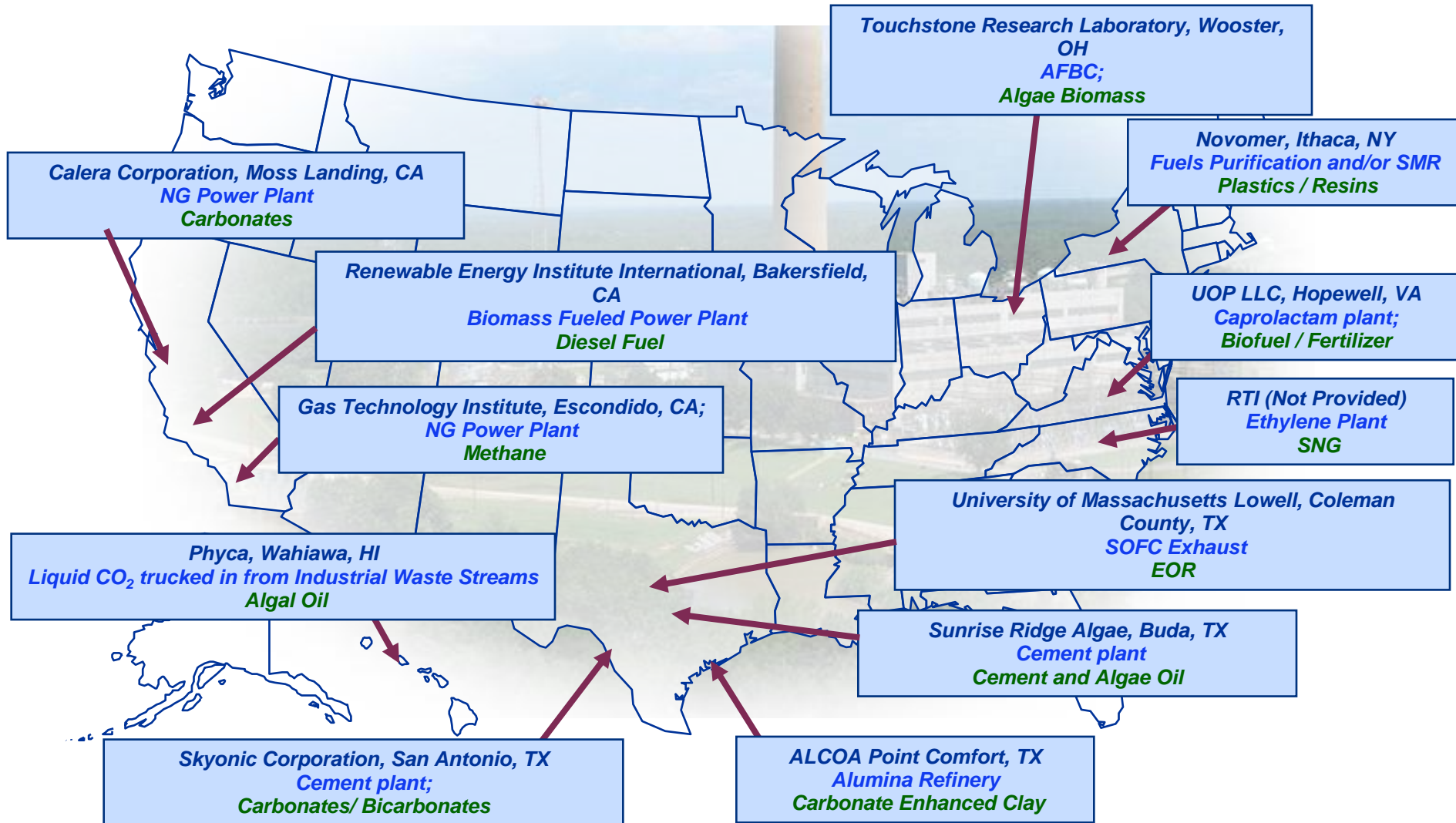
**Company - Project Location**  
**Industry Type – Product**  
**Sequestration Type**





# Project Locations for Area 2, Phase 1

## CO<sub>2</sub> Beneficial Reuse



# Geologic Site Characterization

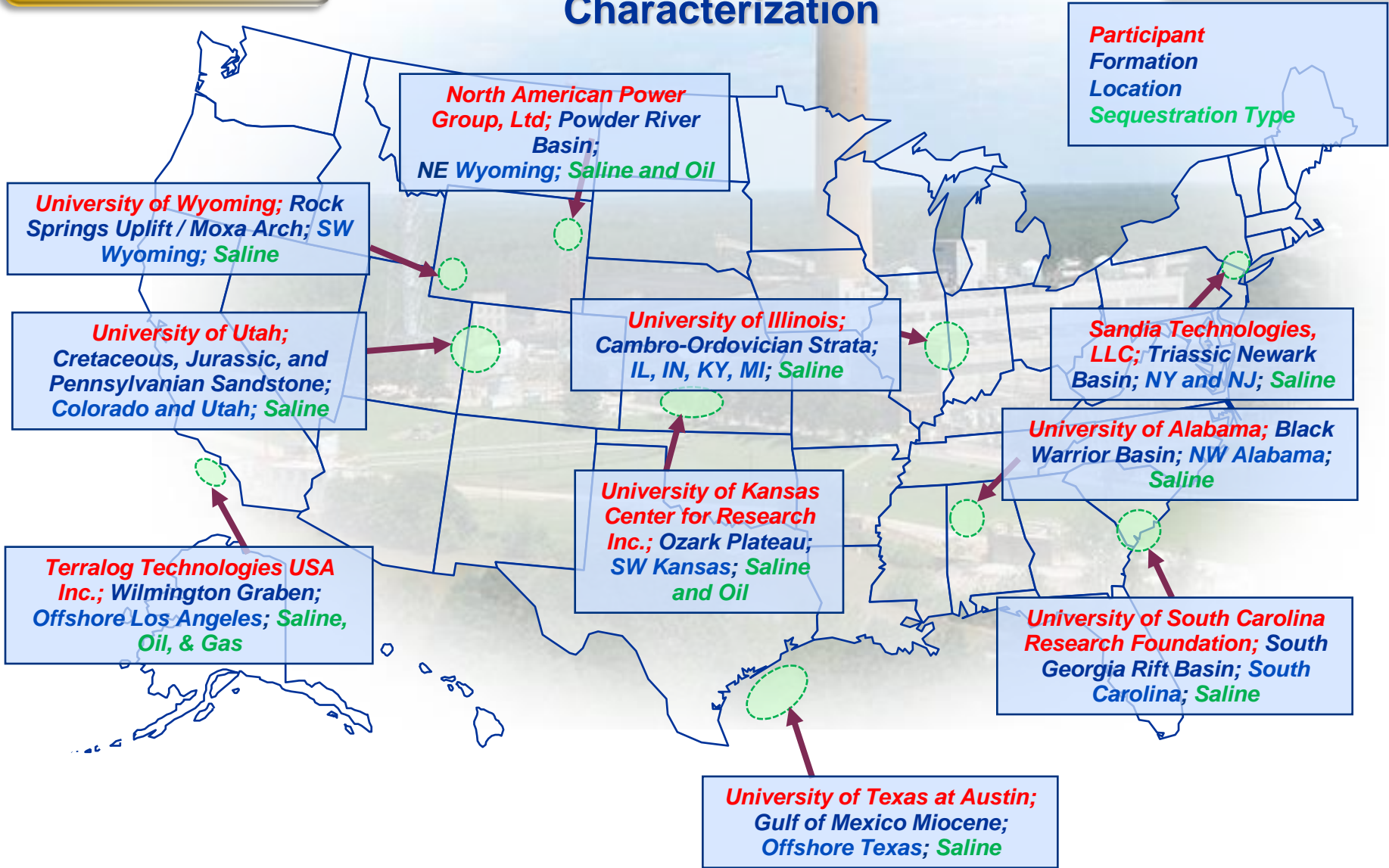


# Site Characterization Overview

- **Goals and Objectives:**
  - Characterize a minimum of 10 “high-potential” geologic formations
    - Saline formations, depleting/depleted oil fields, or coal seams
    - Focus on a minimum of one specific site, formation, or area not previously characterized with public data
    - Represents a significant storage opportunity in the region with adequate seals that could be developed commercially in the future
    - Increase understanding of the potential for these formations to safely and permanently store CO<sub>2</sub>
- **Planned Awards:**
  - At least 10 Cooperative Agreement Awards
- **DOE Funding/Award Size:**
  - \$49.75M / Approximately \$5M each
- **Cost Share:** at least 20%
- **Performance Period:** 3 years



# 2009 ARRA Selected Site Characterization



# Geologic Sequestration Training and Research Activities



# Sequestration Training and Research Goals

- Develop a Future Generation of Geologists, Scientists, and Engineers needed to Provide the Skills Required for National-Scale, Large-Volume Geologic Storage Projects
- Advance Educational Opportunities Across a Broad Range of Colleges and Universities
- Implement Regional Technology Training that focuses on the Applied Science and Engineering Required for CCS Projects

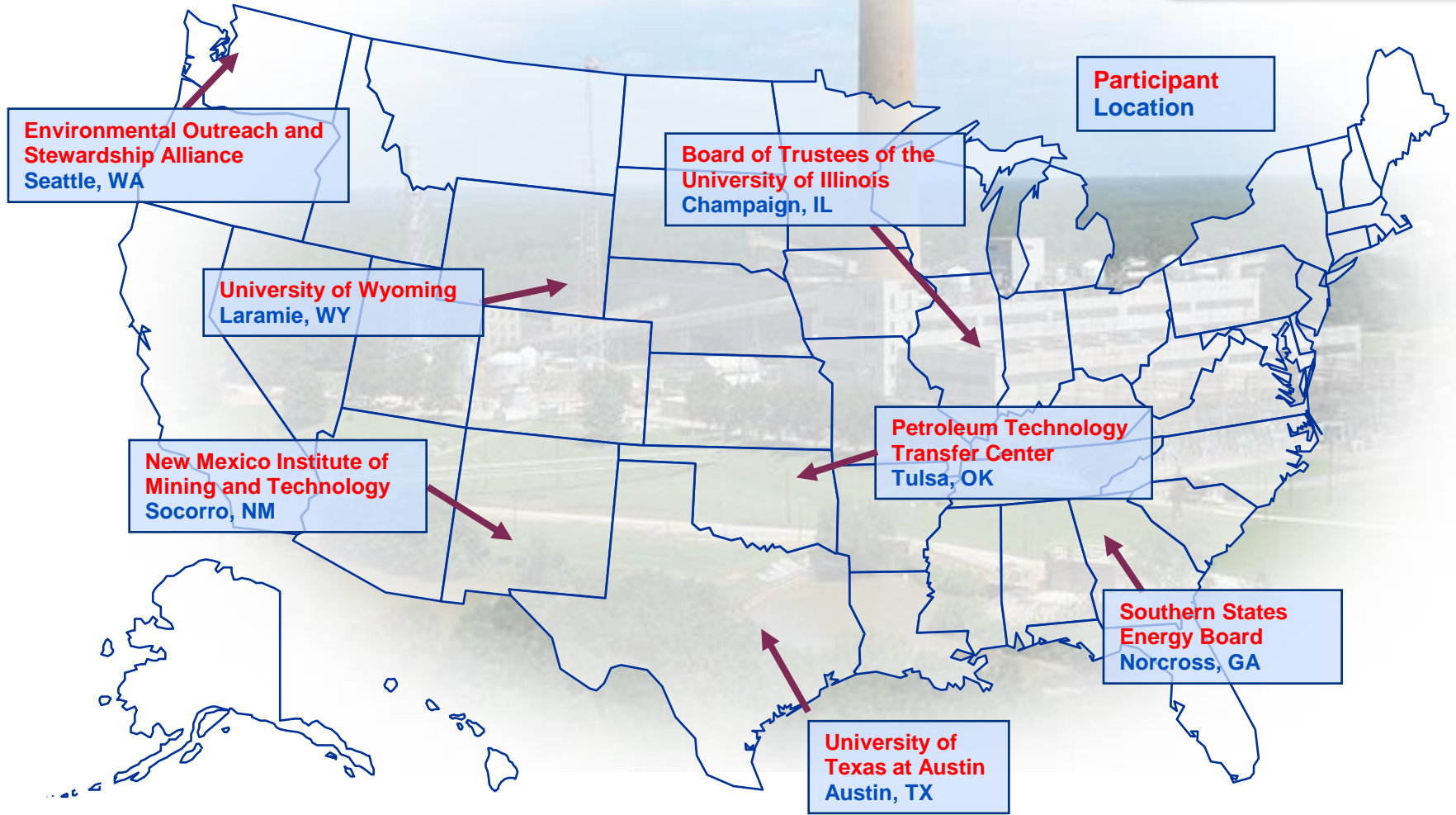


# Major Planned Program Milestones

Milestone	Geologic Sequestration Training and Research	
	<i>Universities and Colleges</i>	<i>Establish CCS Training Centers</i>
Complete 1 <sup>st</sup> Training Classes – All Learning Centers	N/A	09/30/10
100 Professionals Trained	N/A	07/31/11
250 Professionals Trained	N/A	04/30/12
Complete Training Center Workshops – 500 Professionals Trained	N/A	12/10/12
100 Undergraduate and Graduate Students Trained	12/23/12	N/A
Project Complete	12/23/12	12/10/12



# 2009 ARRA CCS Training Center Selections



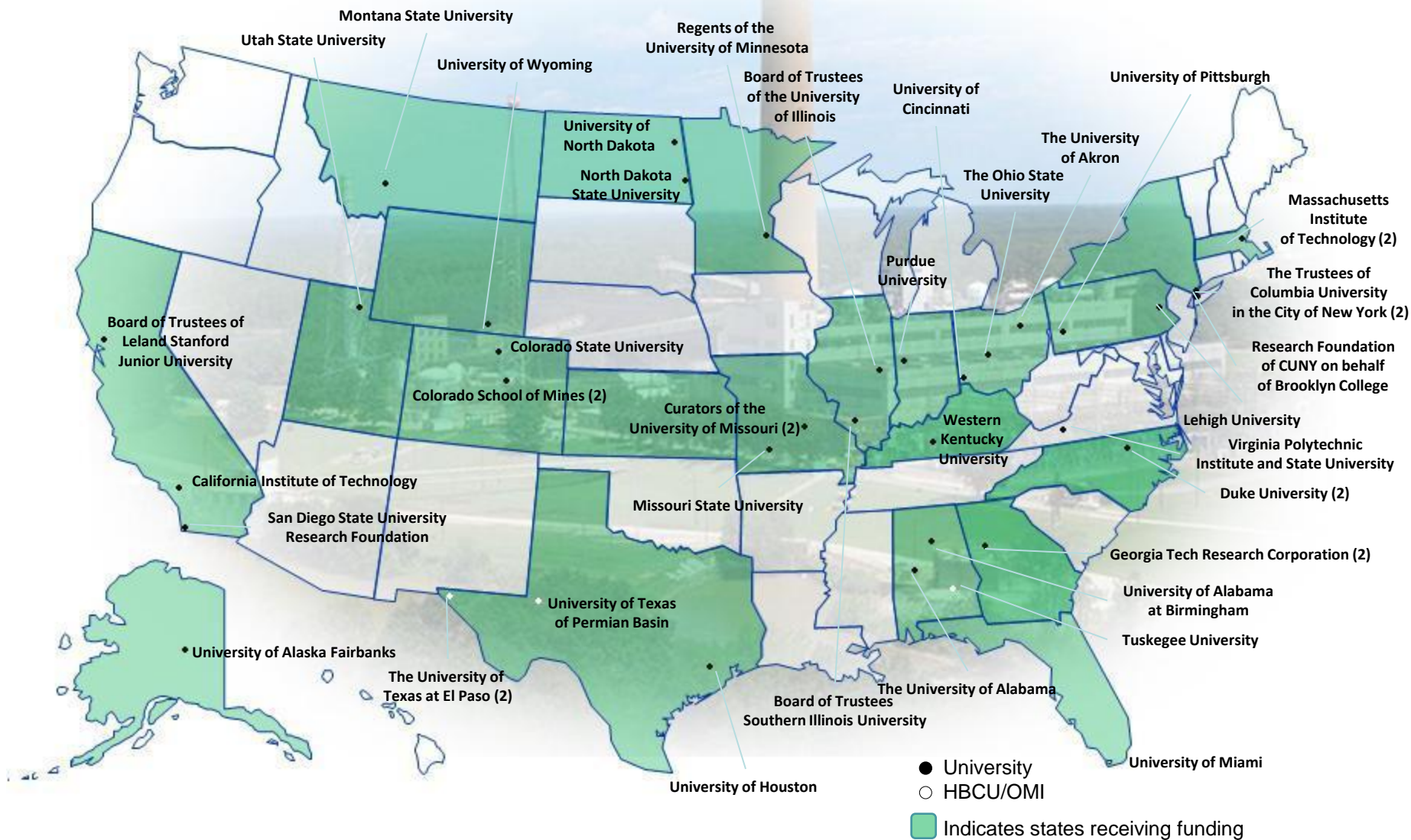
	# Apps Selected	DOE Cost	Non-DOE Cost	Total Cost
<b>Total</b>	<b>7</b>	<b>\$6,963,187</b>	<b>\$1,507,588</b>	<b>\$8,473,775</b>





**2009 ARRA**

**CCS University Research and Training Grants**



# Summary of Selections

Area of Interest	# of Projects	DOE Share	Cost Share	Total Budget
Simulation and Risk Assessment	20	\$5,975,055	\$524,248	\$6,499,303
Monitoring, Verification, and Accounting	13	\$3,813,065	\$247,712	\$4,060,777
Capture and Transport	5	\$1,494,093	\$0	\$1,494,093
Post-Combustion Capture	5	\$1,501,633	\$130,924	\$1,632,557
Total	43	\$12,783,846	\$902,884	\$13,686,730



# Other CCS Activities



# DOE's Global CCS Demonstration Role

Selected DOE Participation in International CO<sub>2</sub> Storage Projects

<i>Location</i>	<i>Operations</i>	<i>U.S. Invol.</i>	<i>Reservoir</i>	<i>Operator /Lead</i>	<i>Int'l Recognition</i>
North America, Canada <b>Saskatchewan</b> Weyburn-Midale	1.8 Mt CO <sub>2</sub> /yr commercial 2000	2000-2011	oil field carbonate EOR	Encana, Apache	IEA GHG R&D Programme, CSLF
North America, Canada, Alberta Zama oil field	250,000 tons CO <sub>2</sub> , 90,000 tons H <sub>2</sub> S demo	2005-2009	oil field carbonate EOR	Apache (Reg. Part.)	CSLF
North America, Canada, British Columbia Fort Nelson	> 1 Mt CO <sub>2</sub> /yr, 1.8 Mt acid gas/yr large- scale demo	2009-2015	saline formation	Spectra Energy (Reg. Part.)	CSLF
Europe, North Sea, Norway Sleipner	1 Mt CO <sub>2</sub> /yr commercial 1996	2002-2011	marine sandstone	StatoilHydro	IEA GHG R&D Programme, CSLF, European Com.
Europe, Germany CO2SINK, Ketzin	60,000-90,000 tonnes CO <sub>2</sub> demo 2008	2007-2010	saline sandstone	GeoForsch- ungsZentrum, Potsdam(GFZ)	CSLF, European Commission, IEA GHG R&D Prog
Australia, Victoria Otway Basin	100,000 tonnes CO <sub>2</sub> demo 2008	2005-2010	gas field sandstone	CO2CRC	CSLF
Africa, Algeria In Salah gas	1 Mt CO <sub>2</sub> /yr commercial 2004	2005-2010	gas field sandstone	BP, Sonatrach, StatoilHydro	CSLF, European Commission
Asia, China, Ordos Basin	assessment phase CCS	2008-TBD	Ordos Basin	Shenhua Coal	



# Interagency Task Force on CCS

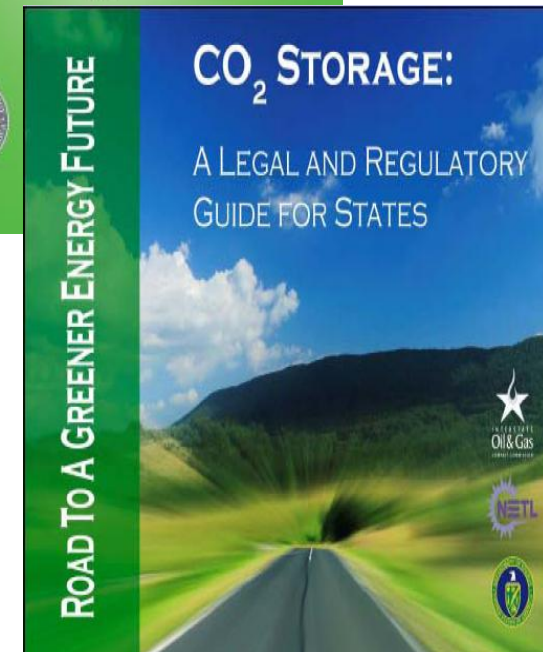
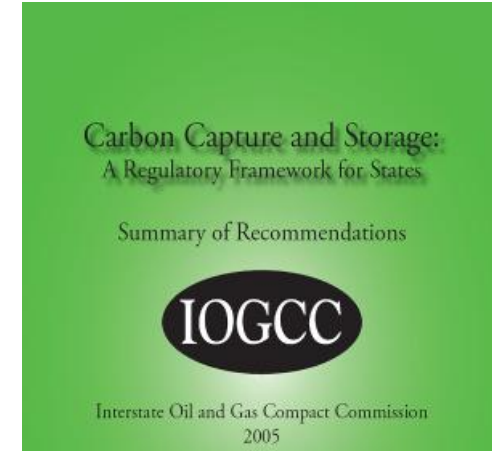
*Goal: Propose a plan to overcome the barriers to the widespread cost-effective deployment of CCS within 10 years with a goal of bringing 5-10 commercial demonstrations online by 2016*

- **Established on February 3, 2010**
- **14 executive departments and agencies**
- **Co-chaired by DOE and EPA**
- **Plan is due in August 2010**
- **First public meeting held May 6, 2010**



# Regulatory Guidelines Emerging

- **EPA & DOE Working Group**
- **EPA Underground Injection Control Program**
  - Class V guidance – March 2007
  - Proposed Class VI Rules – July 2008
  - Notice of Data Availability (NODA) – August 2009
  - Class VI Final Rule – 2010
- **EPA Office of Air and Radiation**
  - Responsible for CO<sub>2</sub> emissions and accounting
- **IOGCC and DOE**
  - Regulatory Framework – 2005
  - Model Regulations – 2008
  - Regulatory Best Practices Manual – 2010
  - CO<sub>2</sub> Pipeline efforts – started in 2009
- **Supporting IRS Rules CO<sub>2</sub> Sequestration Tax Credits**



# Summary

- Continue with large-scale development to verify safe and permanent storage in geologic formations
- Continue to pursue novel technology development to lower capture costs
- Ensure that next generation of scientists and engineers are trained and available
- Continue working with other Federal agencies to ensure necessary legal and regulatory frameworks are in place
- Work with international partners



# More Info...

The screenshot shows the U.S. Department of Energy website. At the top is the DOE logo and the text "U.S. DEPARTMENT OF ENERGY". Below this is a navigation bar with categories: SCIENCE & TECHNOLOGY, ENERGY SOURCES, ENERGY EFFICIENCY, THE ENVIRONMENT, PRICES & TRENDS, NATIONAL SECURITY, and SAFETY & HEALTH. A "FOSSIL ENERGY" button is highlighted. On the left is a sidebar menu with "Carbon Sequestration" selected. The main content area features a header image of a landscape with the text "Carbon Sequestration". Below the image is the section "Key R&D Programs and Initiatives" with a sub-heading "Regional Sequestration Partnerships" and a paragraph describing DOE's nationwide network. A "Read More >" link is provided. To the right is a "RELATED NEWS" section with a list of news items, including "Alabama Project" and "Testing Potential for Combining CO2 Storage with Enhanced Methane Recovery".

U.S. DEPARTMENT OF ENERGY

SCIENCE & TECHNOLOGY ENERGY SOURCES ENERGY EFFICIENCY THE ENVIRONMENT PRICES & TRENDS NATIONAL SECURITY SAFETY & HEALTH

FOSSIL ENERGY

You are here: *Carbon Sequestration*

Fossil Energy  
Clean Coal & Natural Gas Power Systems  
Carbon Sequestration  
Hydrogen & Other Clean Fuels  
Oil & Natural Gas Supply & Delivery  
Natural Gas Regulation  
U.S. Petroleum Reserves

OFFICES & FACILITIES  
Select a Field Site

STAY CONNECTED

QUICK REFERENCE

**Carbon Sequestration**

**Key R&D Programs and Initiatives**

**Regional Sequestration Partnerships**  
DOE has created a nationwide network of federal, state and private sector partnerships to determine the most suitable technologies, regulations, and infrastructure for future carbon capture, storage and sequestration in different areas of the country.  
[Read More >](#)

RELATED NEWS

- > Alabama Project  
Testing Potential for Combining CO2 Storage with Enhanced Methane Recovery
- > More Related News

<http://www.fossil.energy.gov/programs/sequestration/index.html>

[http://www.netl.doe.gov/technologies/carbon\\_seq/index.html](http://www.netl.doe.gov/technologies/carbon_seq/index.html)

<http://www.energy.gov/recovery/index.htm>

