

NETL NATIONAL ENERGY TECHNOLOGY LABORATORY



Sequestration Program

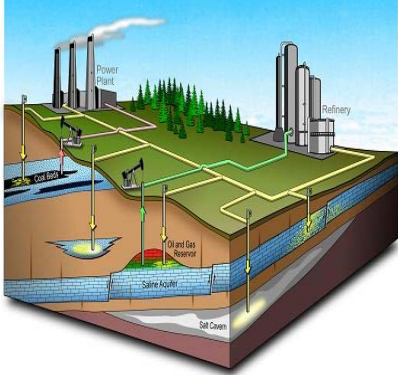
Dawn Deel – Project Manager
September 15-17, 2009



October 2008

Carbon Sequestration Program Goals

- **Deliver technologies & best practices for Carbon Capture and Safe Storage with:**
 - 90% CO₂ capture at source
 - 99% storage permanence
 - < 10% increase in COE
 - Pre-combustion capture (IGCC)
 - < 35% increase in COE
 - Post-combustion capture
 - Oxy-combustion



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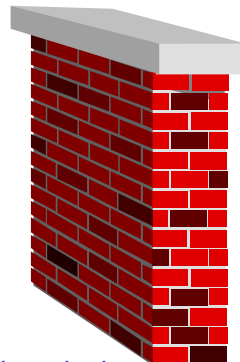
Key Challenges to Carbon Capture and Storage

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 ...

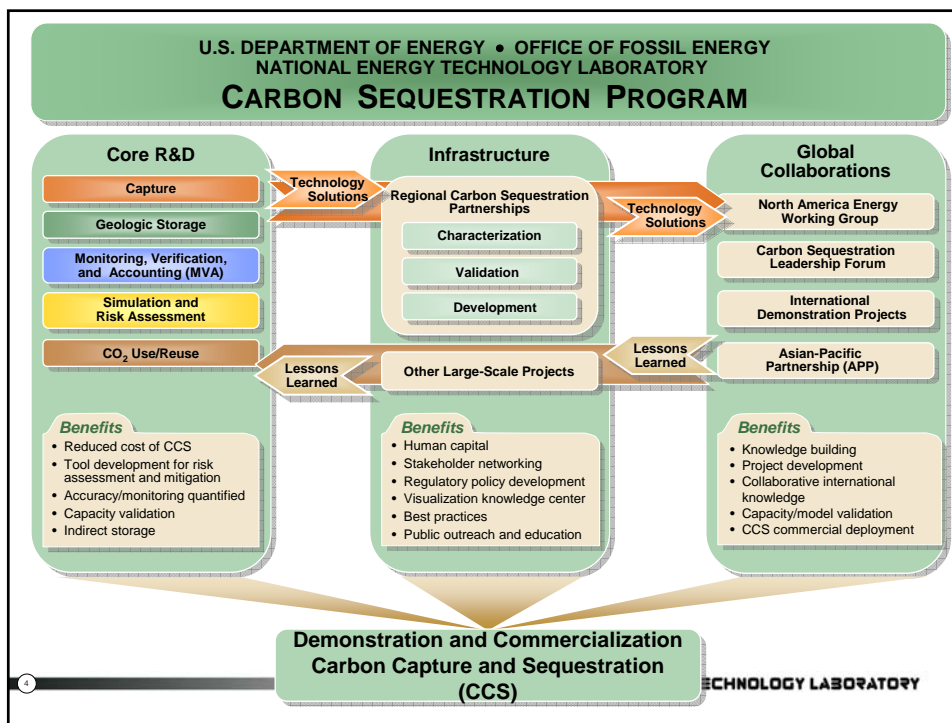
Legal/Social Issues

- **Regulatory Framework**
 - Permitting
 - Treatment of CO₂
- **Infrastructure**
- **Human Capital**
- **Legal Framework**
 - Liability
 - Ownership
 - pore space
 - CO₂
- **Public Acceptance (NIMBY → NUMBY)**

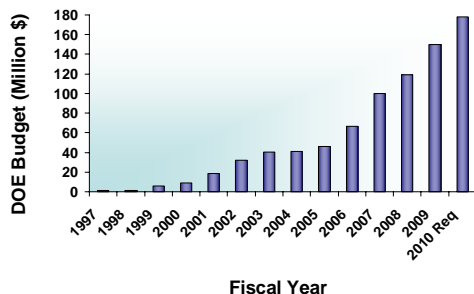


Projects helping to address both categories of issues

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Sequestration Program Statistics FY2009

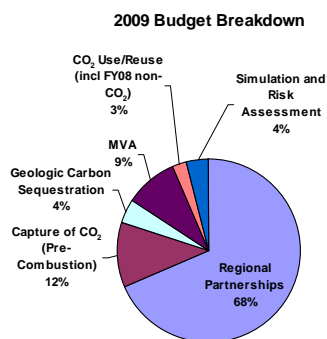


Strong industry support
~ 39% cost share on projects

Federal Investment to Date
~ \$631 Million

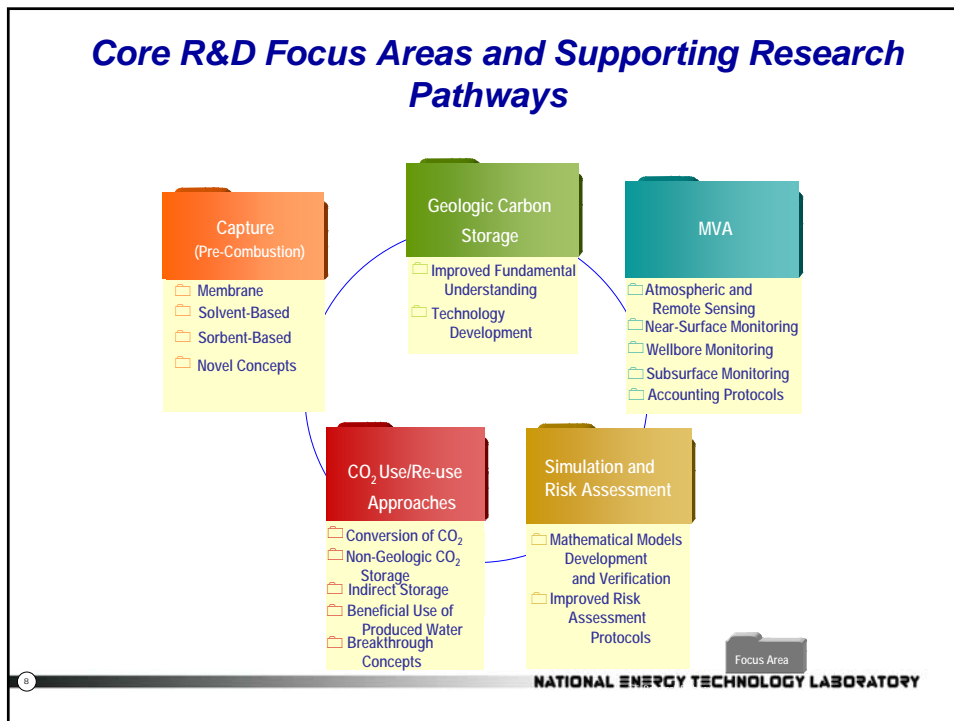
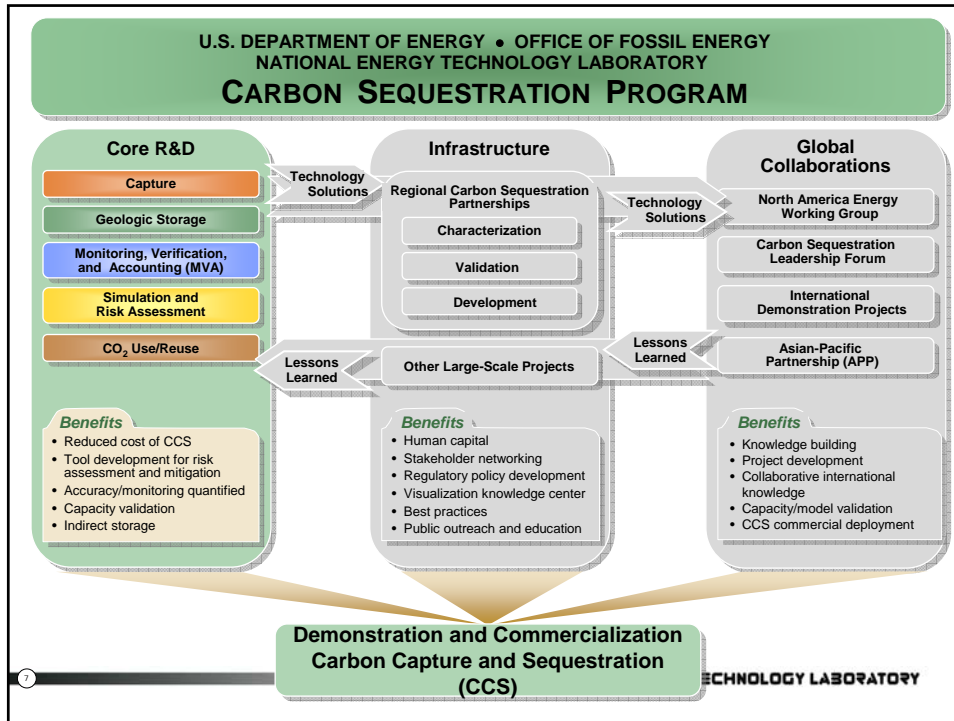
Diverse research portfolio

~ 80 Active R&D Projects



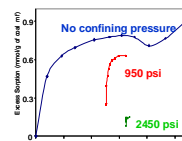
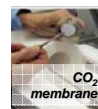
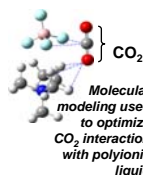
Recent Achievements

- IEA GHG International Review of the Regional Partnership large scale field tests – March 2008
 - RCSP was recognized as most significant program in the world today
 - Excellent program that will achieve significant results
- Carbon Sequestration Atlas - 2nd Edition published November 2008 contains information on stationary sources for CO₂ emissions, geologic formations with sequestration potential, and terrestrial ecosystems with potential for enhanced carbon uptake.
- Produced 1st in series of Best Practice Manuals – *Monitoring, Verification, and Accounting of CO₂ Stored in Deep Geologic Formations*
- Numerous Phase II (Field Validation) Regional Partnership Projects Drilling, Injecting, Completed
- Phase III (Development Test) Regional Partnership Drilling, Injection Started
- Pipeline Study underway
- Two Funding Opportunity Announcements
 - *Pre-Combustion Carbon Capture Technologies for Coal-Based Gasification Plants*
 - *Innovative and Advanced Technologies and Protocols for MVA, Simulation, and Risk Assessment in Geologic Formations*
- Added 43rd State to Regional Carbon Sequestration Partnerships Initiative



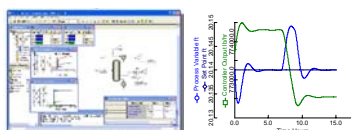
Research at NETL (Office of Research & Development)

- **Carbon Dioxide Capture: Advanced Plants**
 - CO₂ membranes and ionic liquid solvents.
 - Solid sorbents for CO₂ capture and enhanced water-gas-shift.
 - Phase change sorbents and exploratory CO₂ re-use studies.
- **Computational Science/Capture and Power Plant Simulations**
 - Computational chemistry to develop capture materials.
 - Virtual scale-up for capture technologies.
 - Dynamic systems modeling for plants w/capture.
- **CO₂ Storage (Science needs to ensure success of storage projects)**
 - Integrity of seals and wellbores (e.g., cement-CO₂-water reactions)
 - CO₂ tracers with novel collection strategies (NETL designed monitoring packs; bees; airborne methods)
 - Improved assessment of capacity/injectivity w/ site-specific samples
 - Multiphase flow on discrete fractures (experiment and simulation)
 - NETL-led multi-lab initiative on science-based risk assessment
 - LANL, LBNL, LLNL, NETL, PNNL



Determining the effect of confinement on coal storage capacity

Dynamic simulation of IGCC power plant



Experimental models (left) of cement integrity that correctly match field observations (right).

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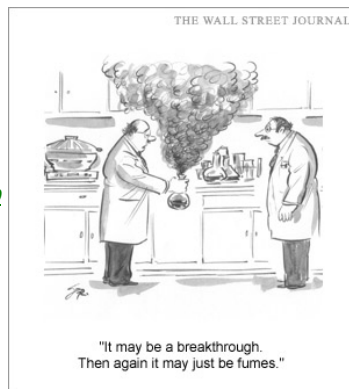
FY09 Program Funding Opportunity Announcements (FOAs)

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

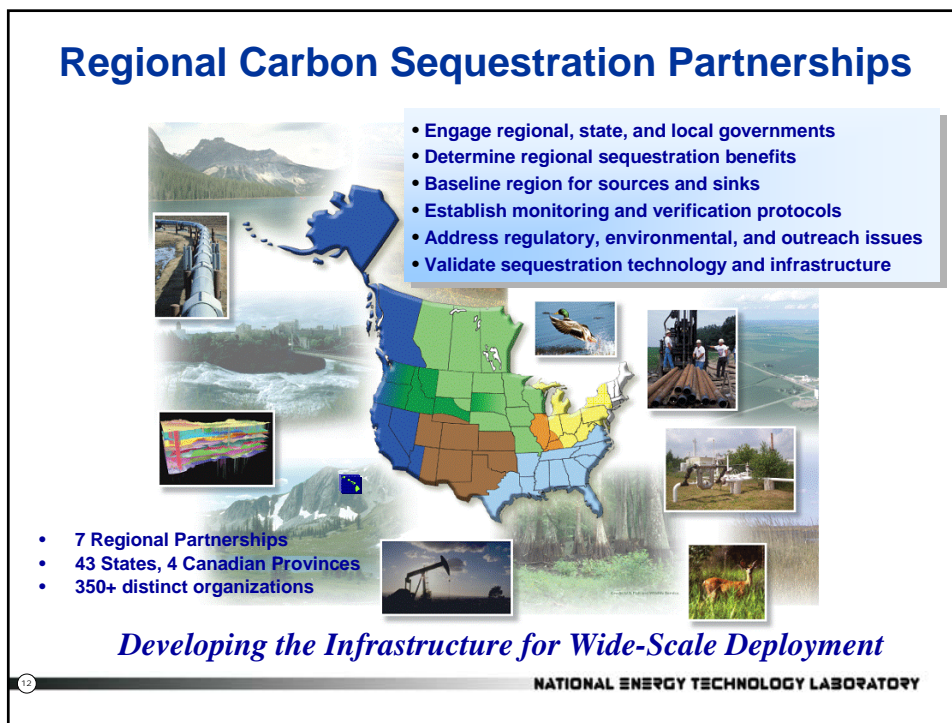
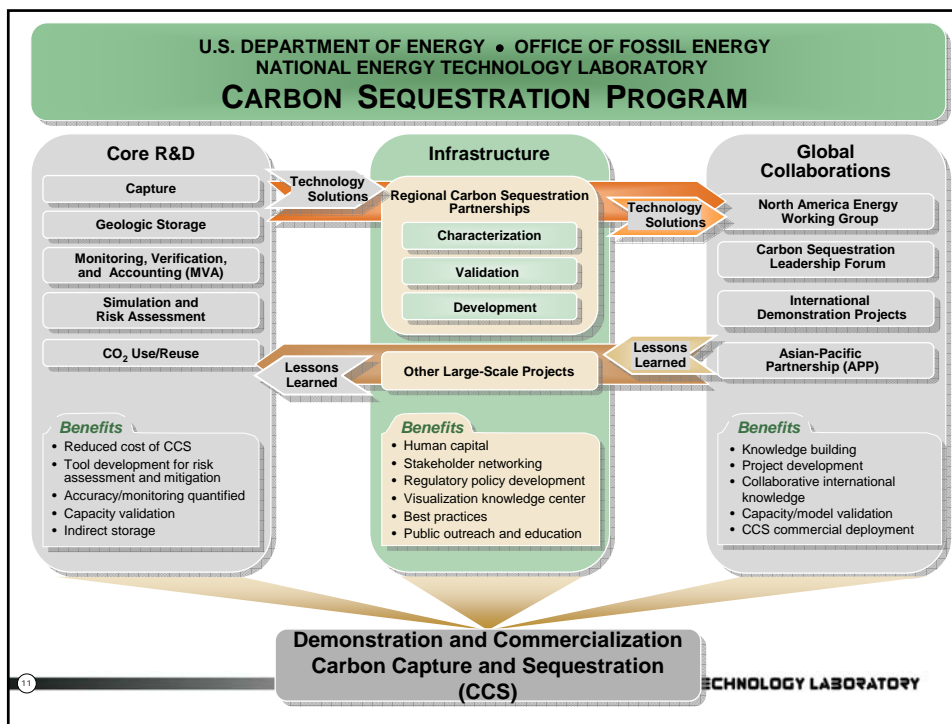
- **Funding Opportunity Announcement [DE-PS26-08NT00699](#)**
- 9 projects selected;
- ~\$14 M total award value over 3-years (\$3.1M Cost-share)
- Project awards by end of FY09
- **Techline at http://www.netl.doe.gov/publications/press/2009/09036-DOE_Awards_Carbon_Capture_Projects.html**

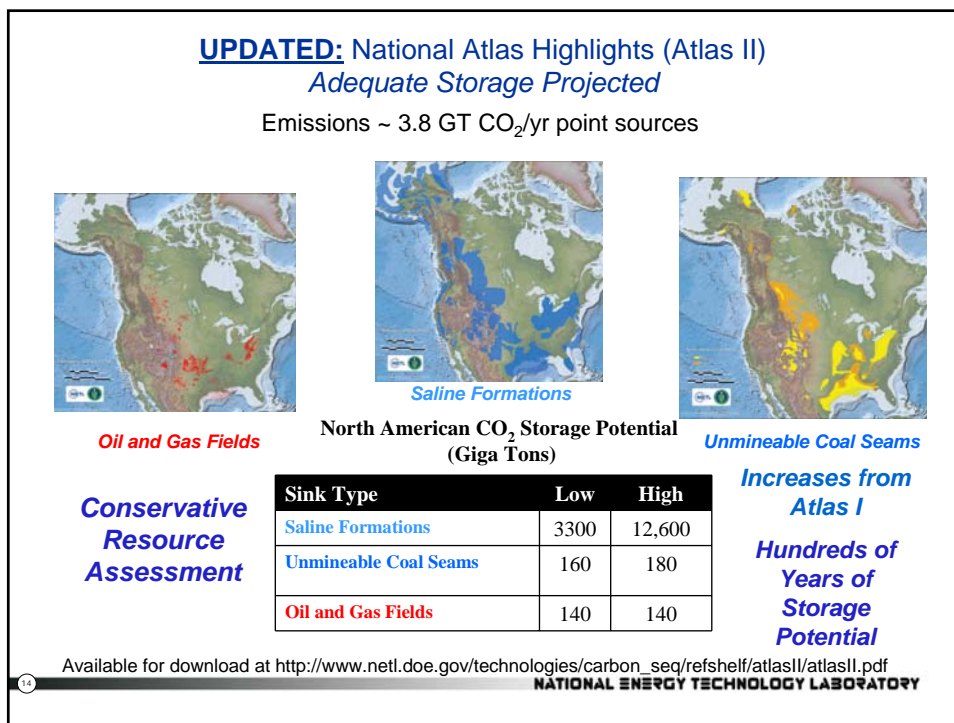
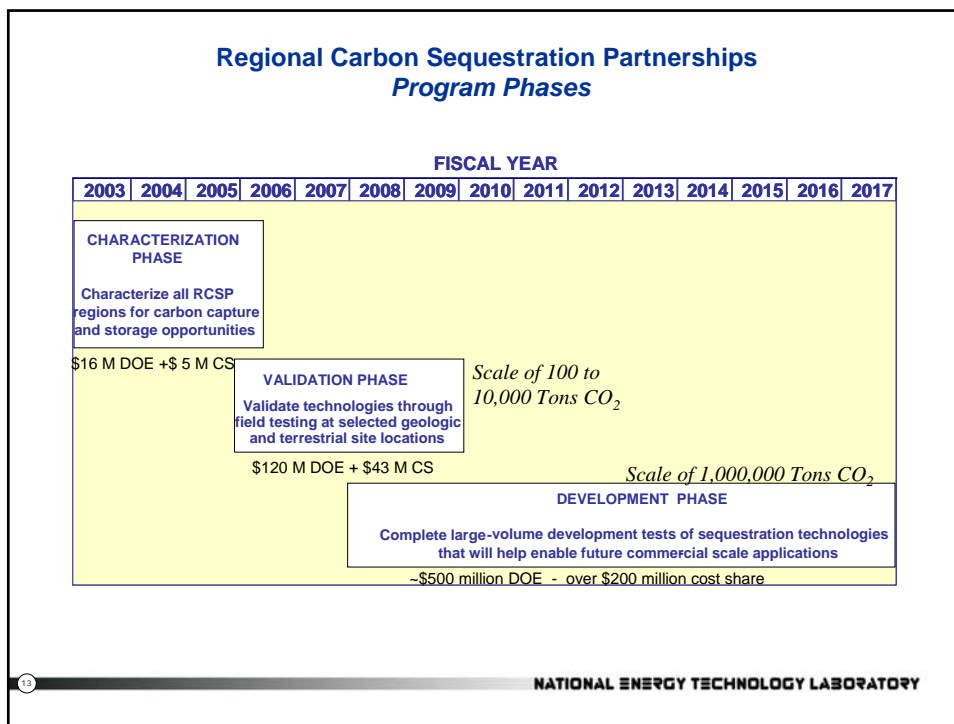
•Innovative and Advanced Technologies and Protocols for MVA, Simulation, and Risk Assessment in Geologic Formations

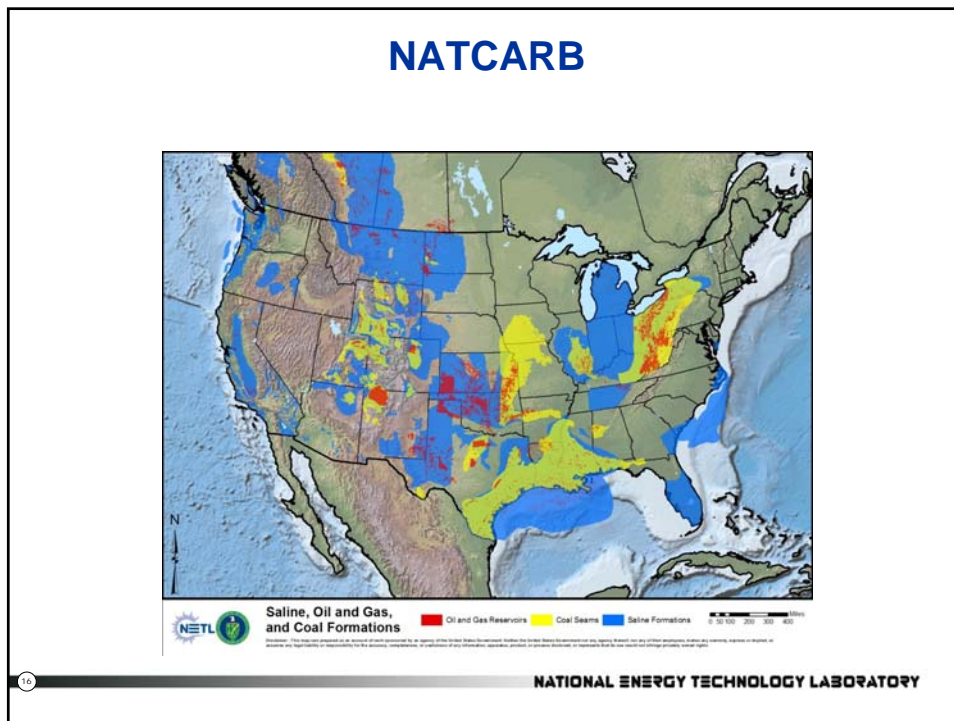
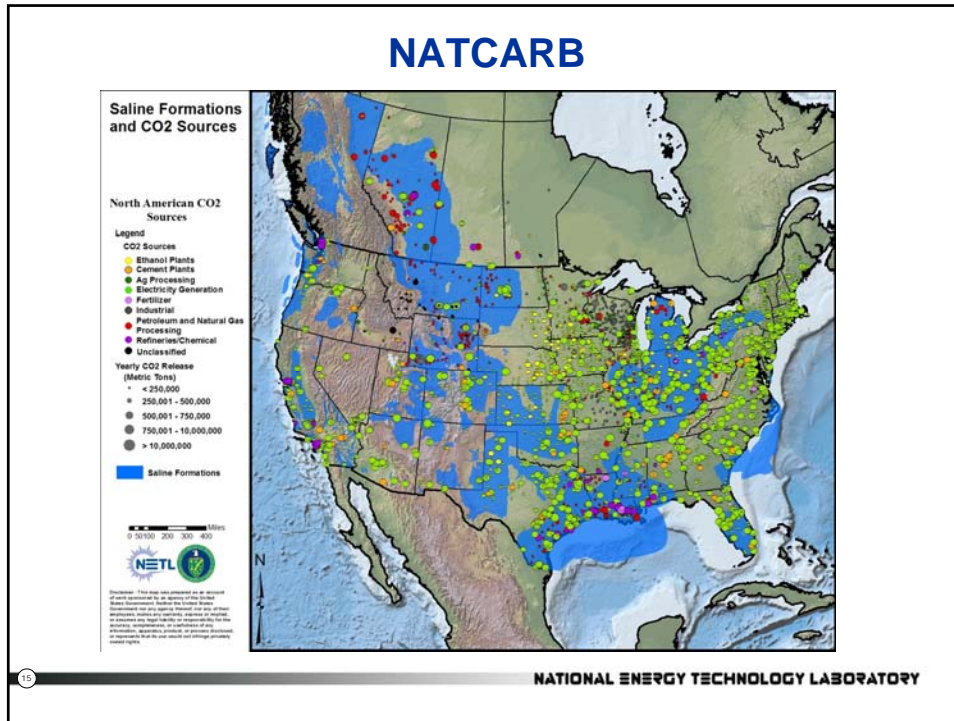
- **Funding Opportunity Announcement [DE-FOA00023](#)**
- Released Feb 18, 2009; Closing Date May 12, 2009
- 19 projects selected;
- ~\$34.7 M total award value over 4 years (\$8.1 M Cost-share)
- Awards Sept-Oct 2009

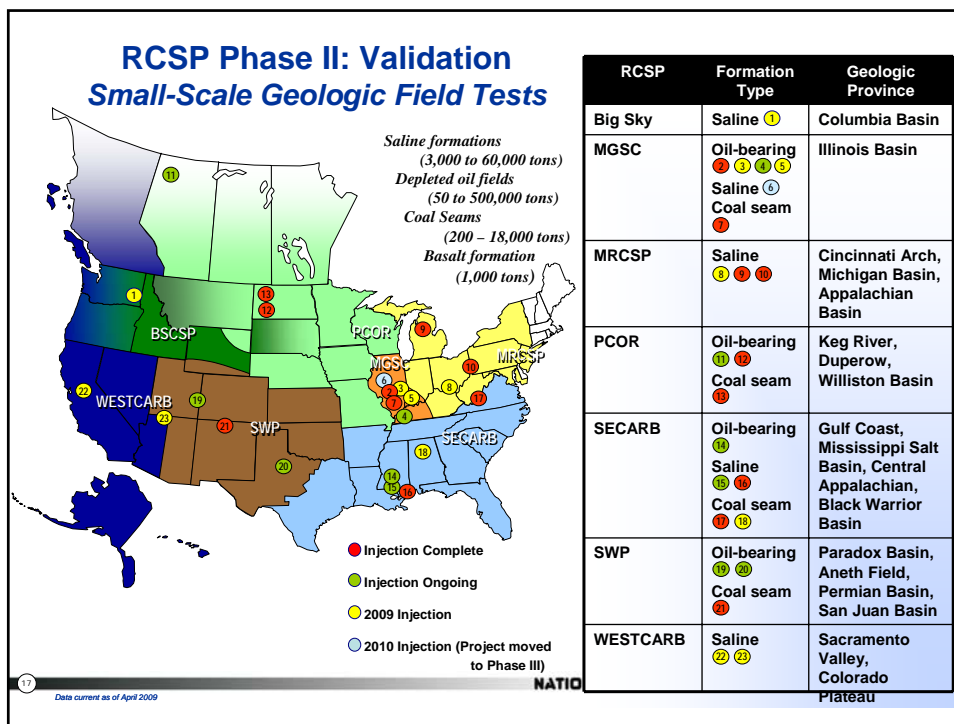


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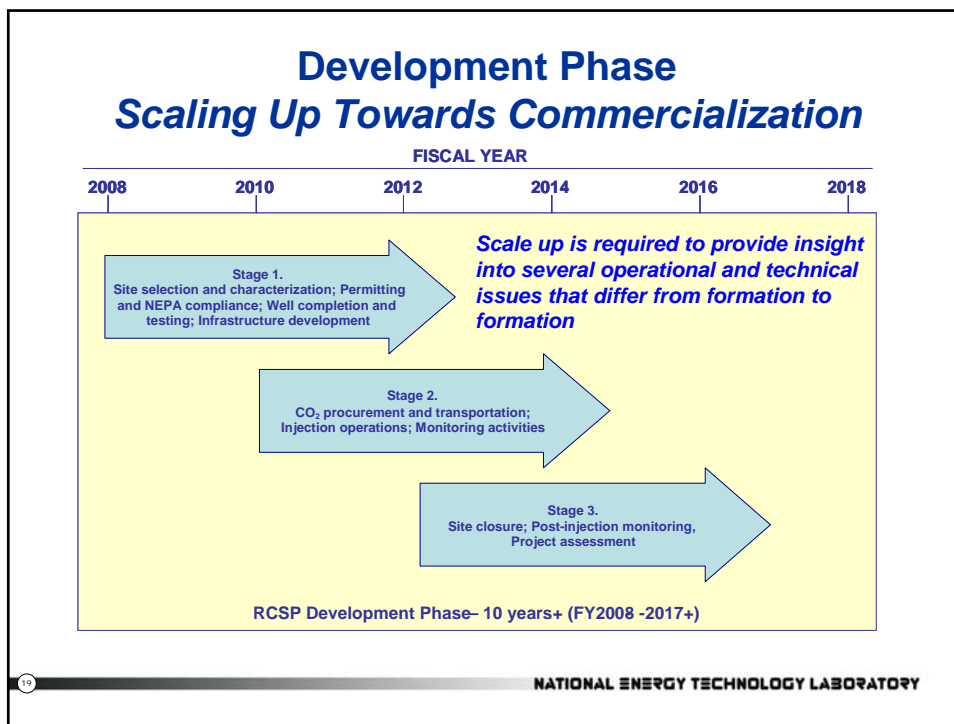


Validation Phase Project Status Geologic Projects

- **Saline formations (3,000 to 60,000 tons)**
 - Projects in Michigan, Mississippi, and Ohio have completed injection
- **Depleted oil fields (50 to 500,000 tons)**
 - Illinois Basin and North Dakota projects complete
 - Currently injecting in Alberta, New Mexico, Utah, Texas, Kentucky, and Mississippi
- **Coal Seams (200 - 18,000 tons)**
 - Central Appalachian project complete
 - Currently injecting in New Mexico, Illinois, North Dakota
- **Basalt formation**
 - Wallula, WA – Grande Ronde Basalt
- **Remaining injection projects scheduled to begin injection by end of 2009**
- *These injection tests lay the foundation and path for larger scale injections and ultimately integrated capture and storage tests*

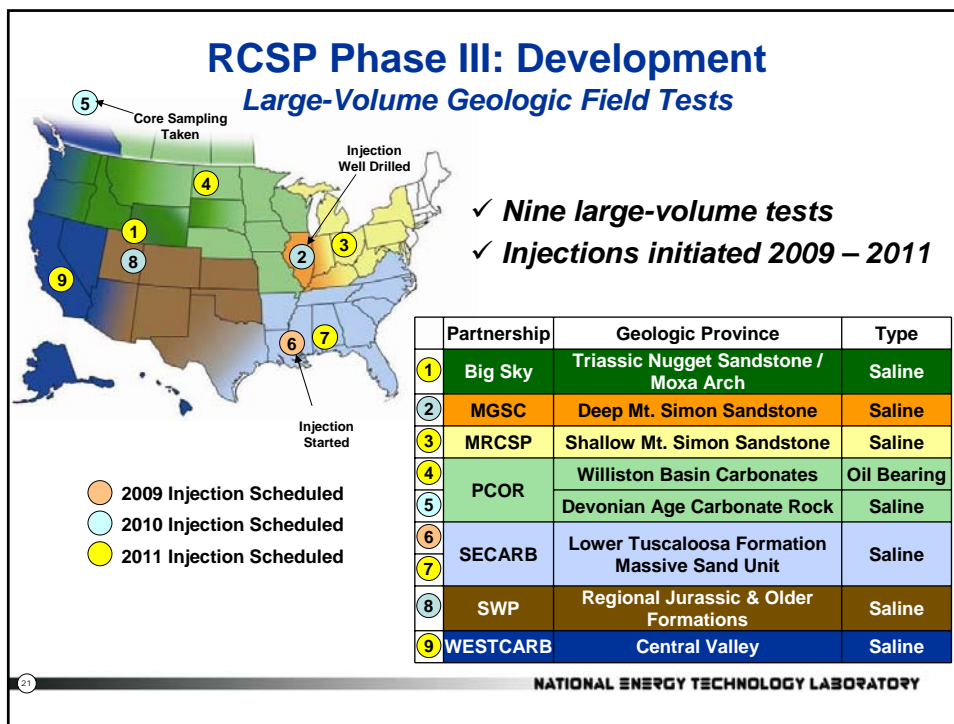
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Development Phase Goals

- Assess
 - Injectivity and Capacity
 - Storage Permanence
 - Areal Extent of Plume and Leakage Pathways
- Develop
 - Risk Assessment Strategies
 - Best Practices for Industry
- Engage in Public Outreach and Education
- Support Regulatory Development

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CCS Best Practice Manuals

Critical Requirement For Significant Wide Scale Deployment
Capturing Lessons Learned

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

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DOE's Global CCS Demonstration Role on Six Continents

Selected DOE Participation in International CO₂ Storage Projects

Location	Operations	U.S. Invol.	Reservoir	Operator /Lead	Int'l Recognition
North America, Canada Saskatchewan Weyburn-Midale	1.8 Mt CO ₂ /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 ₂ , 90,000 tons H ₂ S demo	2005-2009	oil field carbonate EOR	Apache (Reg. Part.)	CSLF
North America, Canada, British Columbia Fort Nelson	> 1 Mt CO ₂ /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 ₂ /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 ₂ demo 2008	2007-2010	saline sandstone	GeoForschungsZentrum, Potsdam(GFZ)	CSLF, European Commission, IEA GHG R&D Prog
Australia, Victoria Otway Basin	100,000 tonnes CO ₂ demo 2008	2005-2010	gas field sandstone	CO2CRC	CSLF
Africa, Algeria In Salah gas	1 Mt CO ₂ /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	

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Questions ?

