

Recent CCS Developments in the United States

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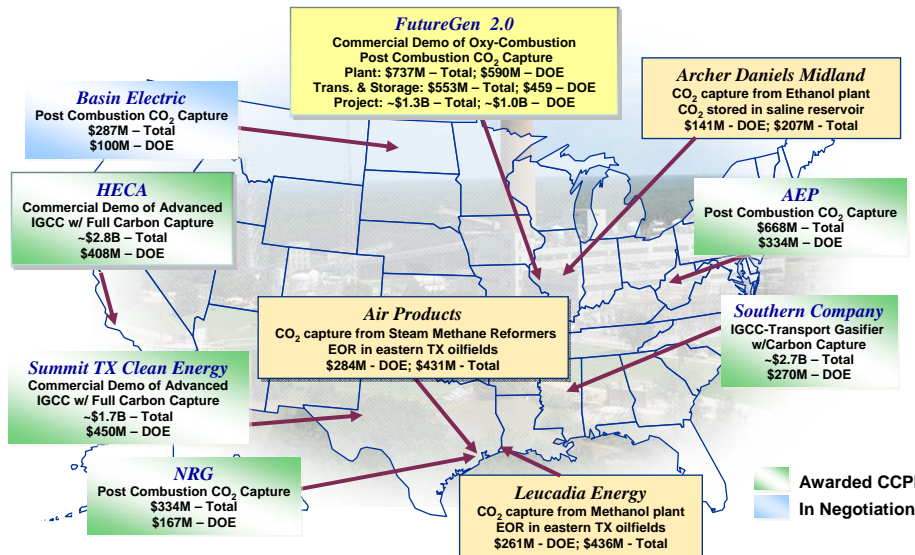
Three Topics

- Major CCS demonstration projects
- Regional Partnership projects
- Recent regulatory developments

CCS Demonstration Projects

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Active CCS Demonstration Projects Locations & Cost Share



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DOE-Supported Demonstration Projects

Performer	Location	Capture Technology	Capture Rate (m tons/y)	Target Formation	Start Date
PC Power Plants					
NRG Energy	Thompsons, TX	Amine	~0.5	EOR	2015
American Electric Power	New Haven, WV	Chilled Ammonia	1.5	Saline	2015
FutureGen Alliance	Meredosia, IL	Oxy	1.0	EOR/Saline	2015
IGCC Power Plants					
Summit Texas Clean Energy	Odessa, TX	Selexol	3.0	EOR	2014
Southern Company	Kemper County, MS	Selexol	2.0	EOR	2014
Hydrogen Energy California	Kern County, CA	Rectisol	2.0	EOR/Saline	2016
Industrial Processes					
Leucadia Energy Lake Charles	Lake Charles, LA	Rectisol	4.0	EOR	2014
Air Products	Port Arthur, TX	Amine	1.0	EOR	2013
Archer Daniels Midland	Decatur, IL	Amine	1.0	Saline	2014

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American Electric Power Co. (AEP)

Advanced Post Combustion CO₂ Capture

- New Haven, WV
- 235 MWe slipstream at AEP's 1300 MWe Mountaineer Plant
- 90% CO₂ capture (Alstom Chilled Ammonia Process); 1,500,000 tons CO₂/year
- Deep saline sequestration in the Rose Run and Copper Ridge formations (Start: 2015)
- Total Project: \$668 Million
Share: \$334 Million (50%)
- Status

DOE



- **FEED in progress**
- **NEPA in progress**

Phase	Description	Federal	Recipient	Total
1	Project Definition and FEED	\$19.5M	\$19.5M	\$39M
2	Detailed Design and Permitting	\$64M	\$64M	\$128M
3	Construction and Startup	\$221M	\$221M	\$442M
4	Operations	\$29M	\$29M	\$58M

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FutureGen 2.0

Oxy-Combustion w/CO₂ Sequestration

- Meredosia, IL; Sequestration site Morgan County, IL
- 200 MWe Gross oxy-combustion repowering of Ameren Unit 4 steam turbine
- 90% CO₂ capture (cryogenic separation); 1,300,000 tons CO₂/year
- Deep saline sequestration in the Mt. Simon formation (Start: 2016)
- Total Project: \$1.3 Billion
DOE Share: \$1.05 Billion (81%)
- Status
 - Pre-FEED in progress
 - Site selection for injection sequestration complete



and

	Federal	Recipient	Total
Phase 1: Pre-FEED	\$29.4M	\$2.7M	32.1M
Phase 2: FEED and Financial Close	\$55.4M	\$8.4M	63.8M
Phase 3 & 4 : Construction and Operations	\$962.6M	\$230.1M	1192.7M

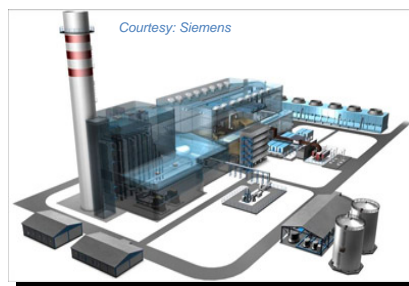
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NATIONAL ENERGY TECHNOLOGY LABORATORY

Summit Texas Clean Energy

Advanced IGCC with full CO₂ Capture

- Penwell, Ector County, TX
- 400 MWe (gross) Greenfield integrated gasification combined cycle (IGCC) employing Siemens Gasification and Power Block – all fully warranted (2 Siemens gasifiers)
- PRB subbituminous coal fuel
- 90% CO₂ capture (Linde Rectisol® Chilled Methanol Process); ~3,000,000 tons CO₂ per year
- Enhanced oil recovery (EOR) with sequestration in the Permian Basin oilfields in West Texas (Start: 2014)
- Total Project: \$1.727 Billion
\$450 Million (26%)
- Status
 - FEED and NEPA in progress



DOE:

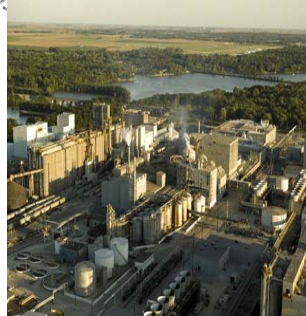
	Federal	Recipient	Total
Phase 1: Definition (FEED)	\$ 23.2M	23.2M	46.4M
Phase 2: Design	\$184.8M	\$ 184.8M	\$ 369.6M
Phase 3: Construction	\$239.1M	\$1065.7M	\$1304.8M
Phase 4: Demonstration	2.9M	2.9M	\$ 5.8M

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Archer Daniels Midland Company

CO₂ Capture from Biofuel Plant

- Decatur, Illinois
- Up to 95% CO₂ capture - dehydration (via tri-ethylene glycol) and compression; **1,000,000 tons CO₂/year**
- CO₂ is a by-product in the production of fuel grade ethanol via anaerobic fermentation
- Sequestration in the Mt. Simon Sandstone, a saline reservoir (Start: July 2013)
- Total Project: \$207 Million
DOE Share: \$141 Million (68%)
- Status
 - Design in progress
 - NEPA in progress



	Federal	Recipient	Total
Phase 1: Project Definition	\$1.5M	\$0.9M	\$2.4M
Phase 2a: Design	\$6.1M	\$1.8M	\$7.9M
Phase 2b Construction	\$122.4M	\$34.6M	\$157.0M
Phase 2c : Operations	\$11.4M	\$29.2M	\$40.6M

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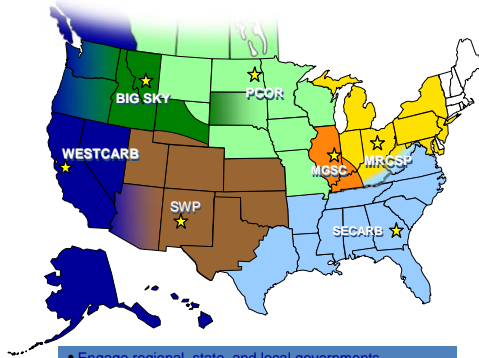
Regional Partnership Projects

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Regional Carbon Sequestration Partnerships

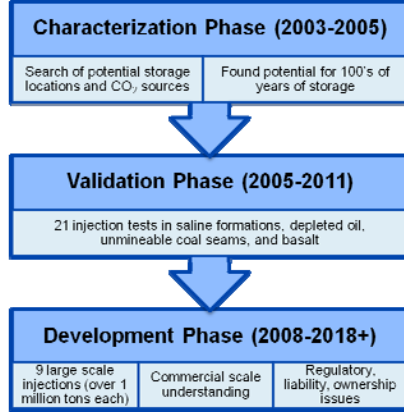
Seven Regional Partnerships

Developing a distinct organizational structure for each state to support development



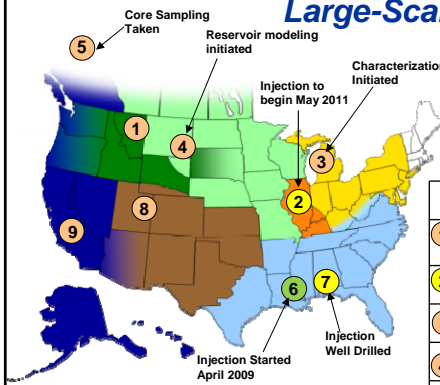
- Engage regional, state, and local governments
- Determine regional sequestration benefits
- Baseline region for sources and sinks
- Establish monitoring and verification protocols
- Address regulatory, environmental, and outreach issues
- Validate sequestration technology and infrastructure

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RCSP Phase III: Development Phase

Large-Scale Geologic Tests



- Injection Ongoing
- 2011 Injection Scheduled
- Injection Scheduled 2012-2015

Note: Some locations presented on map may differ from final injection location

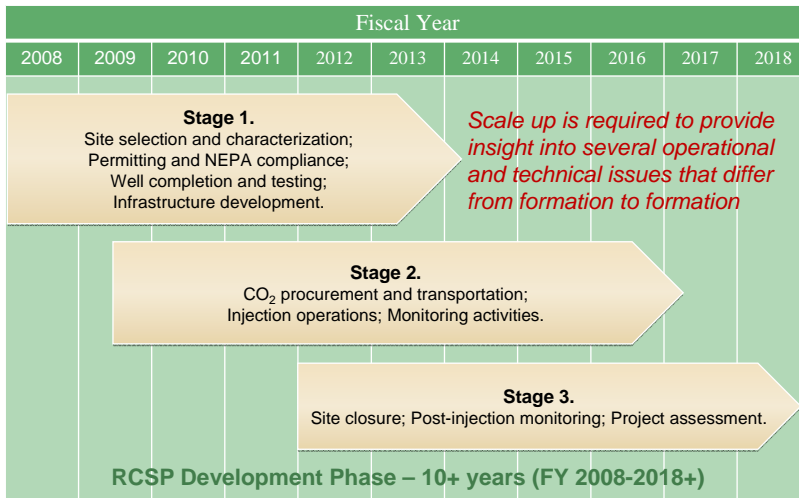
- ✓ Large-volume tests
- ✓ One injection commenced April 2009
- ✓ Remaining injections scheduled 2011-2015

	Partnership	Geologic Province	Target Injection Volume (tonnes)
1	Big Sky	Nugget Sandstone	2,000,000
2	MGSC	Illinois Basin-Mt. Simon Sandstone	1,000,000
3	MRCSP	Michigan Basin-St. Peter Sandstone	1,000,000
4	PCOR	Powder River Basin-Bell Creek Field	1,500,000
5		Horn River Basin-Carbonates	2,000,000
6	SECARB	Gulf Coast - Cranfield Field- Tuscaloosa Formation	2,902,000
7		Gulf Coast - Paluxy Formation	450,000
8	SWP	Regional Jurassic & Older Formations	1,000,000
9	WESTCARB	TBD	TBD

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RCSP Development Phase

Scaling Up Towards Commercialization



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Southeast Regional CS Partnership

Large-Scale Project Site – Saline “Early Test”

Target Formation

- Cranfield Oil Field
- Massive Sandstone Lower Tuscaloosa

CO₂ Source

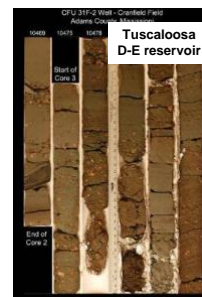
- Jackson Dome (natural source) delivered via Denbury Resources’ Sonat CO₂ pipeline

CO₂ Injection Amount (Current)

- > 2.0 million metric tons (P3 only)
- > 2.7 million metric tons (combined P2 and P3)

Current Status

- Injection began on 04/01/2009
- Injection rate is ~ 432 metric tons/day
- Observation wells (F2 and F3) are from 220 to 370 feet from injection well
- Electrical Resistivity Tomography (ERT) receivers were installed in the two observation wells



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Southeast Regional CS Partnership Large-Scale Project Site – Anthropogenic Test

Target Formation

- Citronelle Dome
- Paluxy Formation

CO₂ Source

- Southern Company's Plant Barry Power Station

CO₂ Injection Amount

- ~ 300,000 metric tons over 3 years (2011)

Current Status

- Capture Unit groundbreaking at Southern Company's Plant Barry coal-fired power plant (April 2010)
- Commenced baseline characterization
- Environmental Information Volumes (EIV) completed
- Expect final Environmental Assessment (EA) and Finding of No Significant Impact (FONSI) January 2011



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Midwest Geological Sequestration Consortium Large-Scale Project Site – Illinois Basin

Target Formation

- Mt. Simon Sandstone, Illinois Basin
- Injection well: 7,230 ft deep

CO₂ Source

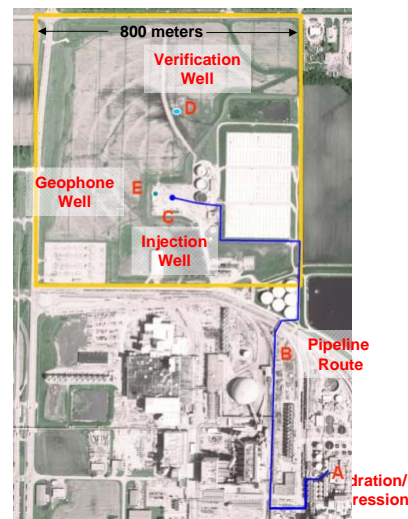
- ADM's ethanol production facility

CO₂ Injection Amount

- 1 million metric tons over 3 years (April 2011)

Current Status

- Completed drilling injection well with micro-seismic sensors and geophone well
- Completed 4 square mile 3D seismic survey
- Groundwater monitoring wells completed
- Compression/dehydration facility expected to be operational by March 2011
- Working on environmental baseline
- Drilling of the observation well completed
- Well casing will be perforated at the monitoring zones following approval of UIC permit modification
- Permit in final appeal period



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Midwest Regional CS Partnership Large-Scale Project Site – Michigan Basin

Target Formation

- Michigan Basin (Otsego County)
- St. Peter Sandstone (Primary)
- Bass Islands Dolomite (Secondary)

CO₂ Source

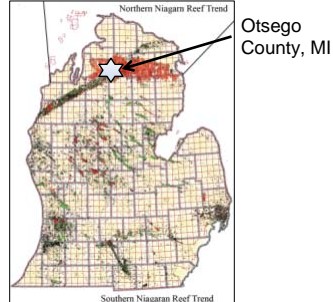
- Core Energy provider per natural gas processing facility

CO₂ Injection Amount

- 1 million metric tons over 4 years (2011/2012)

Current Status

- Completing preliminary geologic assessment of Otsego County area
- Completed “Communications Plan” and met with various stakeholders including government and regulatory agencies
- Initiated Environmental Assessment (EA) Process



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Midwest Regional CS Partnership Otsego County (Michigan Basin) – Characterization Plan



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Midwest Regional CS Partnership

Otsego County (Michigan Basin) – FEP Risk Screening

- **Preliminary Risk Screening completed:**

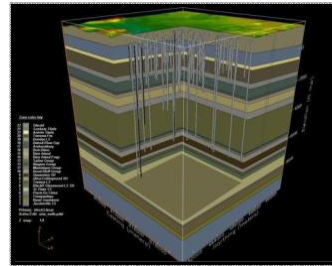
- Features, Events and Processes (FEP) performance and safety screening to identify possible risk items
- “Activity Based Analysis” used to identify leakage pathways and other risks to receptors in the area
- Initial risk matrix prepared

Activity Based Analysis

- Node 1: Pre-Drill Planning
- Node 2: Drilling / Monitoring Injection Well
- Node 3: Well Completion
- Node 4: CO₂ Pipeline Transport
- Node 5: Injection
- Node 6: Site / Well Closure
- Node 7: Post Injection Containment
- Node 8: Project Management
- Node 9: Maintenance and Workover Programs

- **Preliminary Conclusions:**

- No FEP items significantly affect the proposed project
- Existing boreholes are a potential risk pathway present in the area. However, most do not penetrate the St. Peter formation
- Some risk pathways need to be better defined with site characterization



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Plains CO₂ Reduction Partnership

Large-Scale Project Site – Ft. Nelson

Target Formation

- Horn River Basin, British Columbia
- Elk Point Group/Sulphur Point Formation

CO₂ Source

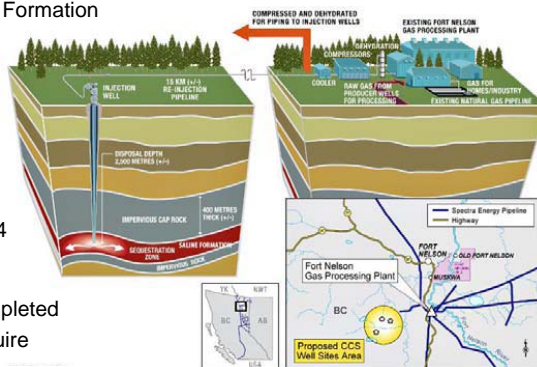
- Spectra Energy’s Fort Nelson natural gas processing plant

CO₂ Injection Amount

- Up to 2 million tons/year
- Injection anticipated early 2014

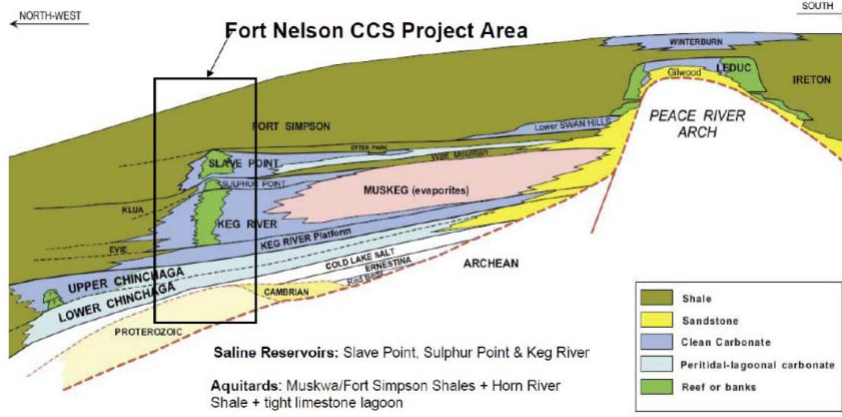
Current Status

- Drilling of exploration well completed
- Conducted “side-track” to acquire additional reservoir data
- Developing integrated Risk Management Plan (RMP), Modeling and MVA Program



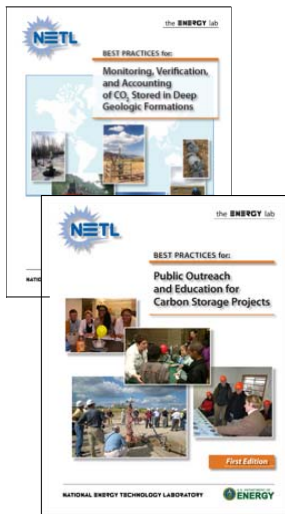
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Plains CO₂ Reduction Partnership Ft. Nelson (Horn River Basin) – Site Geology



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CCS Best Practice Manuals Appearing Critical Requirement For Significant Wide-Scale Deployment — Capturing Lessons Learned



Best Practices Manual	Version 1 (Phase II)	Version 2 (Phase III)	Final Guidelines (Post Injection)
Monitoring, Verification and Accounting	2009	2017	2020
Public Outreach and Education	2009	2016	2020
Site Characterization	2010	2016	2020
Geologic Storage Formation Classification	2010	2016	2020
**Simulation and Risk Assessment	2010	2017	2020
**Well Construction, Operations and Completion	2011	2017	2020
Terrestrial	2010	2016 – Post MVA Phase III	

**Regulatory Issues will be addressed within various manuals
http://www.netl.doe.gov/technologies/carbon_seq/refshelf/refshelf.html

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CCS Regulatory Developments

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Federal Legislative Authority for Regulation of CO₂ and CCS

- Clean Air Act Amendments (CAA)
- Safe Drinking Water Act (SWDA)

also,

- Resource Conservation Recovery Act (RCRA)
(defines and regulates hazardous substances)

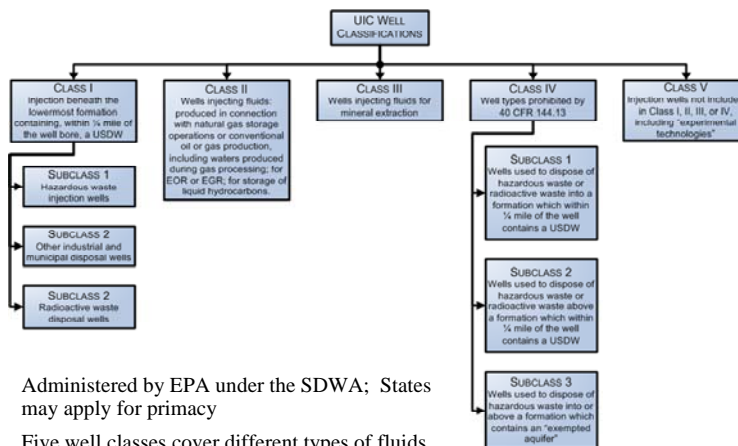
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Federal Regulations

- **GHG Permitting Guidance** (Nov 10, 2010)
 - Subpart C (Stationary Source Power Plants) introduces CCS as a potential option for new or substantially modified sources
- **Mandatory GHG Reporting Rule**
 - Subpart PP (Affected sources) (Dec 17, 2010)
 - Subpart RR (CCS facilities) (Nov 22, 2010)
 - Subpart UU (EOR facilities) (Nov 22, 2010)
- **EPA’s UIC Class VI Rule** (Nov 22, 2010)
- **Proposed CO₂ Rule under RCRA** (*under consideration*)

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Well Classes for the Underground Injection Control (UIC) Program



- Administered by EPA under the SDWA; States may apply for primacy
- Five well classes cover different types of fluids injected

Source: CCSReg.org, 2010

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New UIC Class VI Rule

- Regulates CO₂ injection wells
- Promulgated by EPA under SDWA authority
- Establishes a federal program enforced by States
- Contains provisions for well construction, operation, monitoring, closure, and post-closure
- Financial responsibility documentation must be submitted with permit application and updated annually
- Conversion of an EOR (Class II) well to Class VI to be based on a site-specific risk assessment and threshold (details to be determined)

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Where to Get More Information

- **Websites:**
 - **UIC Class VI rules:**
http://water.epa.gov/type/groundwater/uic/wells_sequestration.cfm
 - **CAA MRR subparts RR and UU:**
<http://www.epa.gov/climatechange/emissions/subpart/rr.html>
<http://www.epa.gov/climatechange/emissions/subpart/uu.html>
 - **CAA MRR Subpart C:**
<http://www.epa.gov/climatechange/emissions/subpart/c.html>
- **People:**
 - **UIC (EPA):** Bruce Kobelski <kobelski.bruce@epamail.epa.gov>
 - **CAA (EPA):** Anhar Karimjee <karimjee.anhar@epa.gov>
 - **RCSP (DOE):** John Litynski <john.litynski@netl.doe.gov>

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Interagency Task Force on Carbon Capture and Storage

- Charged by President Obama in February 2010 with exploring incentives for commercial CCS adoption and addressing any financial, economic, technological, legal, institutional, social, or other barriers to deployment.
- Led by DOE and EPA, more than 100 federal employees from 14 departments and agencies
- Produced an August 2010 report based on published literature plus input from more than 100 experts, stakeholders, and public comments.

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Task Force Recommendations: Regulatory Implementation & Development

- EPA, in coordination with DOE and DOI, should develop capacity-building programs for UIC regulators
- EPA, in consultation with other agencies, should track regulatory implementation for early commercial CCS projects and consider whether additional statutory revisions are needed
- EPA and DOE should identify data needs and tools to support regulatory development, permitting, and project development
- EPA and DOI should immediately formalize coordination and prepare a strategy to develop regulatory frameworks for offshore CO₂ storage

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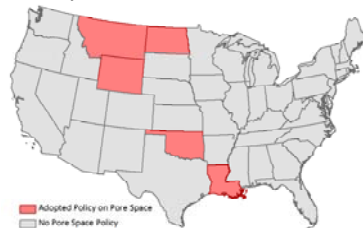
Task Force Recommendations: Long-Term Liability and Stewardship

- Task Force examined seven approaches to address long-term liability including the current framework under existing laws.
 - Task Force agreed that near-term projects can move forward under the existing liability framework and that the option of open-ended Federal indemnification should not be used.
 - Recommended approaches include:
 - Reliance on the existing framework
 - Limitations on claims
 - Creation of a fund for claims and site stewardship
 - Transfer of liability to the Federal government after site closure (with contingencies)
- By late 2011, EPA, DOE, Department of Justice (DOJ), DOI, and Treasury should further evaluate certain approaches to address long-term liability and stewardship.

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States Are Filling Gaps in Federal Regs

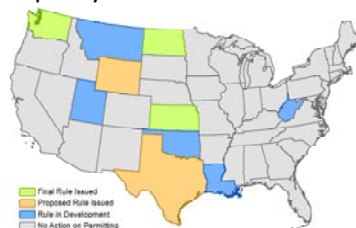
Pore space:



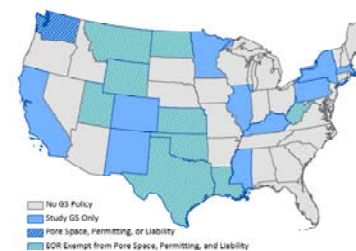
Long-term stewardship:



GS policy:



EOR exclusion:



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Source: CCSReg.org, 2010

For the best summary and analysis of State regs for CCS see:

www.CCSreg.org

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State	Property Rights, incl. Access to Pore Space	Permitting Rules	Long-term Stewardship
Kansas 2009: KAR 82-3-1100-1120 2007: HB 2719	N/A	Agency: KS Corporation Commission. Rules adopted Feb. 2010	State will assume long-term site management, but limited liability. Fund established for long-term monitoring and remediation.
Louisiana 2009: HB 661 2008: HB 1220, 1117	Addresses CO ₂ ownership, liability during operations, and eminent domain. Does not address pore space ownership.	Agency: Office of Conservation, Dept. of Nat. Resources. Rules not yet proposed.	State will assume long-term ownership but limited liability. Fund established for long-term monitoring and limited remediation.
Montana 2009: SB 498	Addresses pore space ownership, liability during operations, mineral rights primacy, CO ₂ ownership, and provides for unitization.	Agency: MT Board of Oil and Gas Conservation, with comments from MT Board of Env. Review. Rules not yet proposed.	State will assume long-term ownership and liability. Fund established for all long-term liabilities.
North Dakota 2009: SB 2095, SB 2139	Addresses pore space ownership, CO ₂ ownership, liability during operations, mineral rights primacy, and provides for unitization.	Agency: ND Industrial Commission. Rules adopted November 2009	State will assume long-term ownership and liability. Fund established for all long-term liabilities.
Oklahoma 2009: SB 610 2008: SB 1765	Addresses CO ₂ status and ownership and mineral rights primacy. Inventory accounting rules adopted. Does not address pore space ownership and liability during operations.	Agency: Corporation Commission for fossil fuel-bearing formations; Dept. of Env. Qual. for all others. Rules not yet proposed.	N/A
Texas 2009: HB 1387, HB1796	Addresses CO ₂ ownership, liability during operations. Does not address pore space ownership.	Agency: Railroad Commission, Texas Commission on Env. Quality. Draft rules issued March 26, 2010	State will assume limited long-term site management but not all liabilities. Fund established for long-term monitoring and limited remediation.
Utah 2008: SB 202	N/A	Agency: Dept. Of Env. Quality. Rules not yet proposed.	N/A
Washington 2008: WAC 173-407-110 2007: ESSB 6001	N/A	Agency: Department of Ecology Rules adopted in 2008.	N/A
West Virginia 2009: HB 2860, W.V. Code, Chap. 22, Art. 11A	Addresses mineral rights primacy. Assigns study group to make recommendations on other issues such as pore space ownership by 2011.	Agency: Dept. of Env. Protection Rules not yet proposed.	N/A
Wyoming 2010: HB 17 2009: HB 57, 58, 80, Water Qual. Rules & Regs. Chap. 24** 2008: HB 89, 90	Addresses pore space ownership, CO ₂ ownership, liability during operations, mineral rights primacy, and provides for unitization.	Agency: Dept. of Env. Quality. Draft rules published 3/13/09, rev. 9/25/09	State will assume limited long-term site management but not all liabilities. Fund established for long-term monitoring.
N/A - Not Addressed	**Proposed Rules		

Source: CCSReg.org, 2010

In Summary

- Significant progress in addressing the technical and regulatory issues associated with large-scale CCS projects in the U.S. at both the federal and state level.
- Major demonstration projects moving forward across the country on a broad spectrum of capture technologies, industrial applications, and geologic formations.
- Still risks associated with project financing. Also need to resolve or clarify several key legal issues, esp. access to pore space and long-term (post-closure) liability.
- *Still need a policy driver for widespread use of CCS.*

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Thank You

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