

Rice Annual Global Engineering and Construction Forum

“Understanding Carbon, Capture and Sequestration”

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Houston Oct 8, 2009



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What's Ahead for CCS

- House passed HR 2454 their climate change & energy bill-cap & trade, geologic sequestration and large incentives for early CCS movers, expanded EPA role
- Senate passed their energy bill-smart grids, renewables, merging of power and carbon markets and Federal indemnification of geologic sequestration
- Senate introduces their climate change language-Kerry - Boxer Bill released very similar to WM
- EPA (WH) aggressively pushing parallel process

Issues for CCS

- Scale
- Infrastructure
- Funding
- Liability
- Land rights issues:
storage space, mineral
rights, surface rights
and access
- Regulatory-Federal and
State
- Water use and access
- Environmental
- Human Resources
- Geographic
- Geologic
- Public Acceptance
- Energy

H.R. 2454, The American Clean Energy and Security Act of 2009 and Kerry-Boxer

- Provide substantial support for early movers in carbon capture and storage
- Bonus allowance for early movers could be as high as \$100/ton (\$106/ton Kerry-Boxer)
- Recognizes the use of geologic sequestration (Section 813)
- Primary sequestration mediums are saline formations, depleted oil and gas fields and deep coal seams
- EPA sets up Task force to study legal framework within six months of enactment and due within 18 months to Congress of enactment could be interpreted as also including BAU Class II EOR wells.
- EPA tasked with establishing itself (1 yr report to Congress), the geologic sequestration regulations (2 yrs), Safe Drinking Water regulations (3 yrs) and requirements for geologic sequestration both subsurface and atmospheric reporting (4 yrs)
- Using Enhanced hydrocarbon recovery results in reduced bonus allowance values at the EPA Administrator's discretion

EPA

- **UIC Codes/Geologic Sequestration Well Protocols-** Docket ID No. EPA-HQ-OW-2008- 0390- Proposed rule: 40 CFR Parts 144 and 146 Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO₂) Geologic Sequestration (GS) Wells
- EPA proposes adding Class VI, MSG proposes Class IIb and Class VII
- Public comment period ended December 24, 2008
- NODA announced with comments due by October 15
- Expect out sometime end 2010 or early 2011
- <http://www.epa.gov/fedrgstr/EPA-WATER/2008/July/Day-25/w16626.htm>
- **Mandatory GHG Reporting-** Docket ID No. EPA-HQ-OAR-2008-0508 FY2008 Consolidated Appropriations Act (H.R. 2764; Public Law 110–161), EPA has proposed a rule that requires mandatory reporting of greenhouse gas (GHG) emissions from large sources(>25,000tns) in the United States.
- Public comment period ended June 9, 2009
- Cleared the OMB September 16
- Industry data collection under the draft rule would begin in January 2010, with the first reports due to EPA in March 2011.
- <http://www.epa.gov/climatechange/emissions/ghgrulemaking.html>
- **Endangerment Finding-**issued under Section 202(a)(1) of the Clean Air Act, **at the OMB now**
- Given that similar endangerment findings serve as the bases for other programs under the Clean Air Act, it is anticipated that, unless Congress acts, EPA will also begin to regulate GHGs from stationary sources and set ambient air quality. The endangerment determination may include an assessment of current and future risks rather than being limited to proof of actual harm.
- EPA cannot control how a federal court would rule in the event of a citizen's suit to force regulation of all sources that emit GHGs in excess of the statutory thresholds.
- *On May 12, EPA Administrator Lisa Jackson told the U.S. Senate Environment and Public Works committee: "It is true that if the endangerment finding is finalized, EPA would have the authority to regulate green-house-gas emissions and...we would be judicious, we would be deliberative, we would follow the science, we would follow the law."*

Senate ACELA 2009 Stewardship (S. 1013)

- **TITLE III—IMPROVED ENERGY SECURITY -PART III—MISCELLANEOUS -Subtitle F—Carbon Capture Sec. 371. Large-Scale Carbon Storage Program (Energy Innovation and Workforce Development in Summary by Bingaman and Murkowski) SB.1013**
- **Facilitates Carbon Capture, Transportation and Storage**
- ***Carbon capture and geologic storage Indemnification (S.1013) legislation establishes a national indemnity program through the Department of Energy for up to 10 commercial-scale carbon capture and sequestration projects to ensure this energy technology is fully realized for the future.***
- **Up to 10 sites**
- **Geographically agnostic—“sites” may possibly aggregation of individual sites**
- **Industrial sources may be aggregated to make 1 million ton hurdle**
- **Brine reservoirs, active and depleted oil and gas reservoirs and “stacked storage” mediums**
- **First come first served for qualifying sites**
- **Secretary must make a determination within 1 year of application**
- **Must comply with Federal and state regulations including protection of USDW**
- **Minimum 10 yrs post closure and meeting requirements**
- **May be some financial assistance**
- **DOE takes over ownership of lands sequestration if not already on Federal lands**

“Carbon Storage Stewardship Trust Fund Act of 2009” S.1502

- Introduced July 22 by Senators Casey (PA) and Enzi (WY). “Carbon Storage Stewardship Trust Fund Act of 2009”
- *To establish a program to be managed by the Department of Energy to ensure prompt and orderly compensation for potential damages relating to the storage of carbon dioxide in geological storage units*
- *Secretary of DOE lead authority, MVA requirements in conjunction with the EPA Administrator*
- *For commercial projects*
- (1) Require private liability insurance for geological storage facility construction, and for carbon dioxide transport, injection, well plugging, site abandonment and post-closure monitoring;
- (2) Establish a Federal trust fund from fees paid for by commercial carbon dioxide storage facility operators that will be used to pay for claims for damages made after storage facility stewardship is transferred to Federal government;
- (3) Establish a Federal program to certify closure of commercial facilities and subsequent transfer of liability for long term stewardship to the Federal government;
- (4) Convey post-closure liability for long-term stewardship of stored carbon dioxide to the Federal government or State upon receipt of certificate of closure; and
- (5) Provide for prompt and orderly compensation for damages or harm from the transport, injection and storage of carbon dioxide in geological storage units.
- Storage site categorized by units
- Not limited by number of sites or volumes
- Storage can be in: saline formations, hydrocarbon formations, basalt formations, salt caverns, unmineable coal seams, or any other geological formation capable of permanently storing carbon dioxide.

Two Markets for Same Molecule

Commodity CO₂ for use in Enhanced Oil Recovery in the US and Globally

Sequestered CO₂ or Greenhouse Gas and resulting tradable offsets or credits

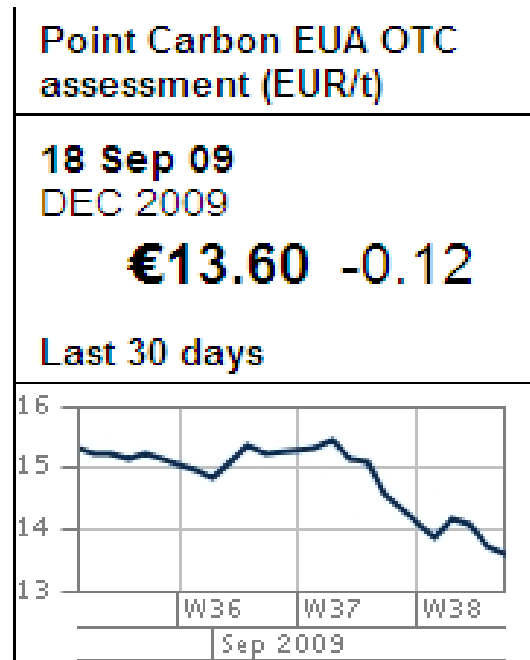
Carbon Capture Storage (CCS) can readily optimize values from both markets

Carbon Market Assessment

Sources: www.pointcarbon.com, www.chicagoclimatex.com, www.rggi.org

European Credits

\$19.99 Euro is 1.47

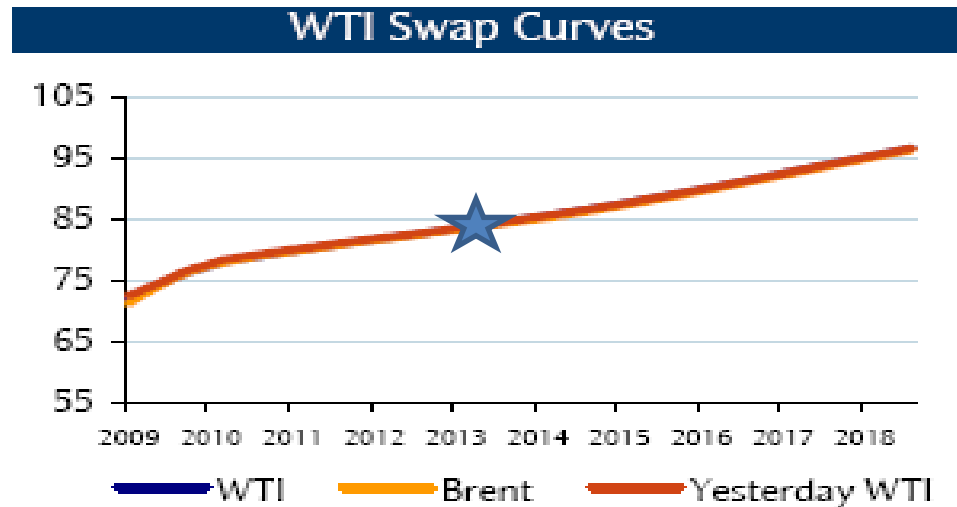


US Markets

- **Chicago Climate Exch.**
2009 \$0.20 OTC 2-3.00
2010 \$0.25
- **RGGI Auction 5 - 9/9/09**
2009--\$2.19
2012--\$1.87
- **OTC Voluntary Offsets**
2009 \$4-7.00

Recent US Commodity CO₂ Assessment

WTI Curve: September 18, Barclays Daily Commodity Report



10 year mid★WTI/Brent Oil price ~\$85.00/bbl. Value of CO₂ created by oil price.
Permian Basin rule of thumb: 1000 cubic ft of CO₂ is valued as 2.0% of bbl of oil
value *delivered to well head*

~\$1.70 mcf

Note: This is an implied value the crude oil quality, field characteristics, CO₂ utilization/bbl and distance to/from markets will influence ultimate commodity CO₂ value/price

Federal CCS Funding Opportunities

U.S. Department of Energy-National Energy Technology Laboratory Recovery Act: Carbon Capture and Sequestration from Industrial Sources and Innovative Concepts for Beneficial CO₂ Use Funding Opportunity Number: DE-FOA-0000015 Announcement Type: Initial CFDA Number: 81.089 Fossil Energy Research and Development.
Announcement June 8, 2009 application due August 7, 2009

- **\$1,321,765,000.00 Available**
- Carbon Capture Storage from Industrial Sources-can be with/from steel, aluminum, cement, manufacturing, muni-waste, petcoke fuel source. Exclusions on power plants with energy output over 50% and fuel is over 55% coal. Efficiency in capture technology min 10% CO₂ content with 75% capture of emitted CO₂ stream storage, 1 million tons/year in CO₂-EOR-EGR, basalt, stacked and ECBM, required site characterizations and MVA as program components
- Phase I: concept and planning. Seven months. 10-12 awards, \$500K to \$3 million. DOE 80% cost share –awards announced 10-2-09
- Phase II: Design, Construction and Operations. 60 months. 4-6 awards must be in Phase I to qualify. \$50 to \$400 million award size. DOE targets 50% but cannot exceed 80% cost share.
- No min-max on awards and qualifications open-financial ability in Phase II. Applications in by August 7, 2009

Interesting Finding on Oil

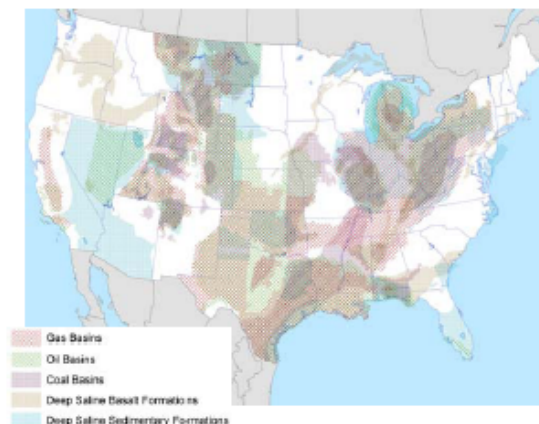
In WM but not in Boxer-Kerry

- ***SEC. 127. OPEN FUEL STANDARD.***
- ***17 (a) FINDINGS.— “The Congress finds that—(1) the status of oil as a strategic commodity, which derives from its domination of the transportation sector, presents a clear and present danger to the United States”;***
- *Final version language on page 120. Language found on page 117 of June 19th HR 2454 this language also found on page 115 of the “Amendment in the Nature of a Substitute” 946 page version of HR 2454 not in the May 21, 932 page version but also on page 33 in the Committee report June 5th.*

Scope of Geologic Sequestration

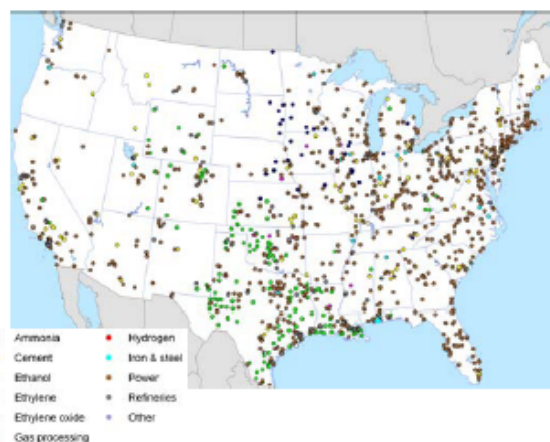
US has the Geologic Capacity

Source: Source: Pacific Northwest National Laboratory Comparing Existing Pipeline Networks with the Potential Scale of Future U.S. CO₂ Pipeline Networks JJ Dooley, RT Dahowski, CL Davidson--Joint Global Change Research Institute Nov 2008



3,900+ GtCO₂ Capacity within 230 Candidate Geologic CO₂ Storage Reservoirs

- ▶ 2,730 GtCO₂ in deep saline formations (DSF) with perhaps close to another 900 GtCO₂ in offshore DSFs
- ▶ 240 Gt CO₂ in on-shore saline filled basalt formations
- ▶ 35 GtCO₂ in depleted gas fields
- ▶ 30 GtCO₂ in deep unmineable coal seams with potential for enhanced coalbed methane (ECBM) recovery
- ▶ 12 GtCO₂ in depleted oil fields with potential for enhanced oil recovery (EOR)



1,715 Large Sources (100+ ktCO₂/yr) with Total Annual Emissions = 2.9 GtCO₂

- 1,053 electric power plants
- 259 natural gas processing facilities
- 126 petroleum refineries
- 44 iron & steel foundries
- 105 cement kilns
- 38 ethylene plants
- 30 hydrogen production
- 19 ammonia refineries
- 34 ethanol production plants
- 7 ethylene oxide plants

NETL Seven Regional Partnerships

http://www.netl.doe.gov/technologies/carbon_seq/partnerships/links.html

National Energy Technology Laboratory
Site Map
GO>




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

ABOUT NETL
KEY ISSUES & MANDATES

Carbon Sequestration
Regional Carbon Sequestration Partnerships – Websites and Contact Information

	Montana State University http://www.bigskyCO₂.org/
	University of Illinois, Illinois State Geological Survey http://www.sequestration.org/
	Battelle Memorial Institute http://www.mrcsp.org
	University of North Dakota, Energy & Environmental Research Center http://www.undeerc.org/pcor/

	Southern States Energy Board http://www.secarbon.org/
	New Mexico Institute of Mining and Technology http://www.southwestcarbonpartnership.org/
	California Energy Commission http://www.westcarb.org/

DOE-ARI US Oil Basin Assessments

OUTLOOK FOR CO₂-EOR

Recently completed “basin studies” of applying “state-of-the-art” CO₂-EOR in the U.S. indicate:

- Nearly 89 billion barrels of technically recoverable resource,
- From 4 to 47 billion barrels of economically recoverable resource.

Results are based on applying streamline reservoir simulation to 1,581 large oil reservoirs (two thirds of U.S. oil production).

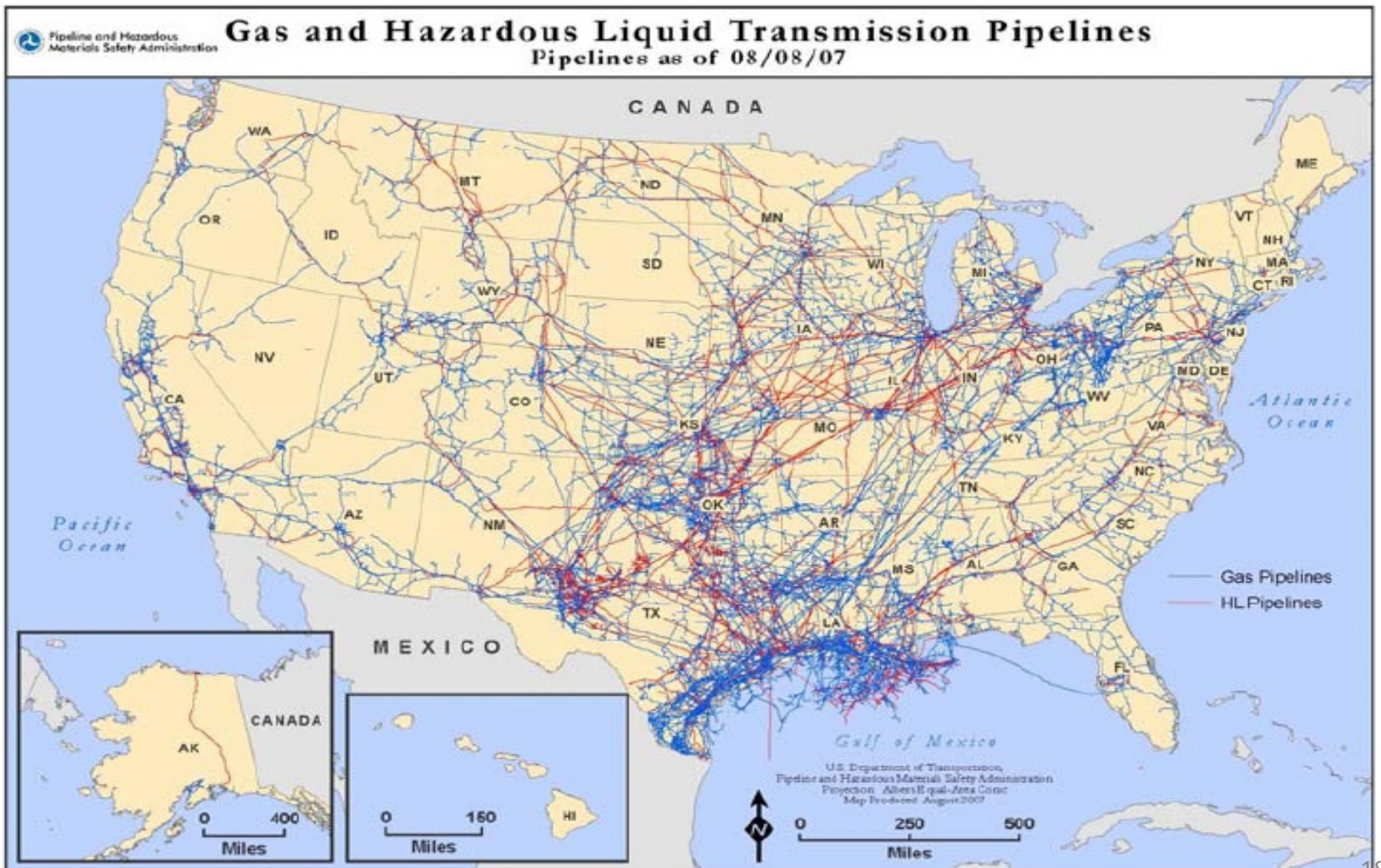
Available on the U.S. DOE web site.

http://www.fe.doe.gov/programs/oilgas/eor/Ten_Basin-Oriented_CO2-EOR_Assessments.html

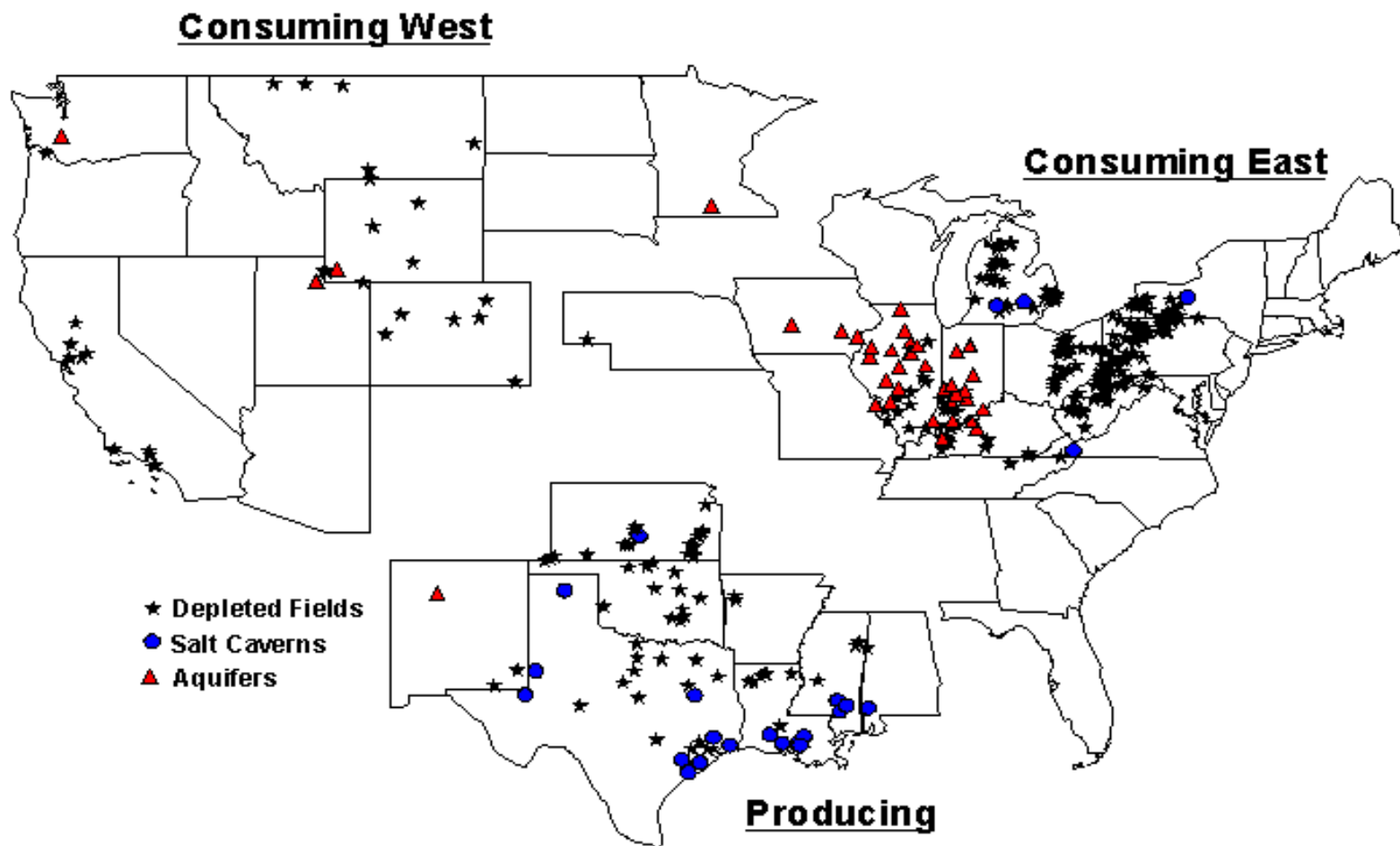


Can We Manage the CO₂ and Sequestration?

480,000 Miles of Natural Gas and HL Pipelines

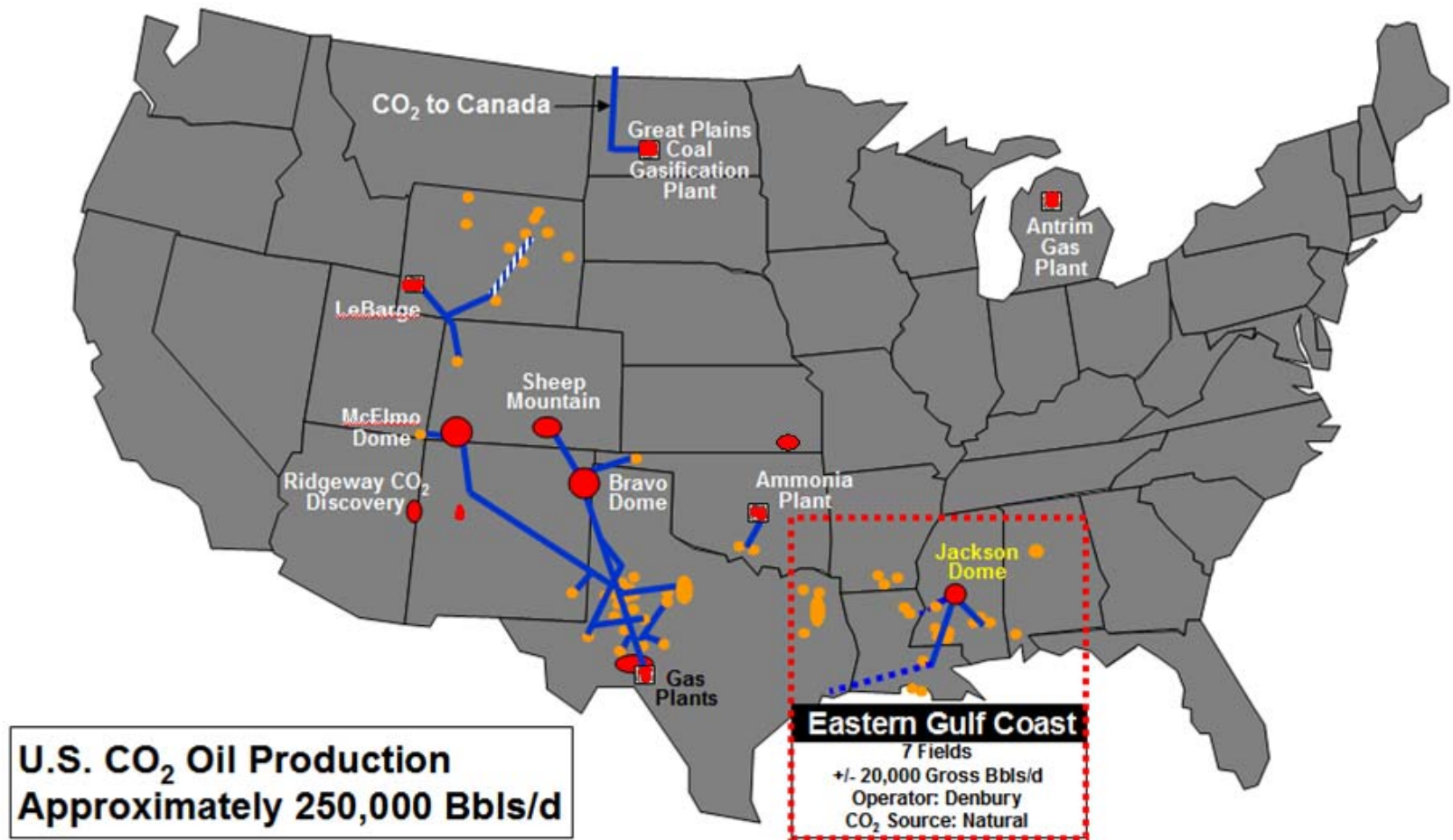


~400 Lower 48 Gas Storage Facilities



Source: Energy Information Administration (EIA), EIA GasTran Geographic Information System Underground Storage Data Base.

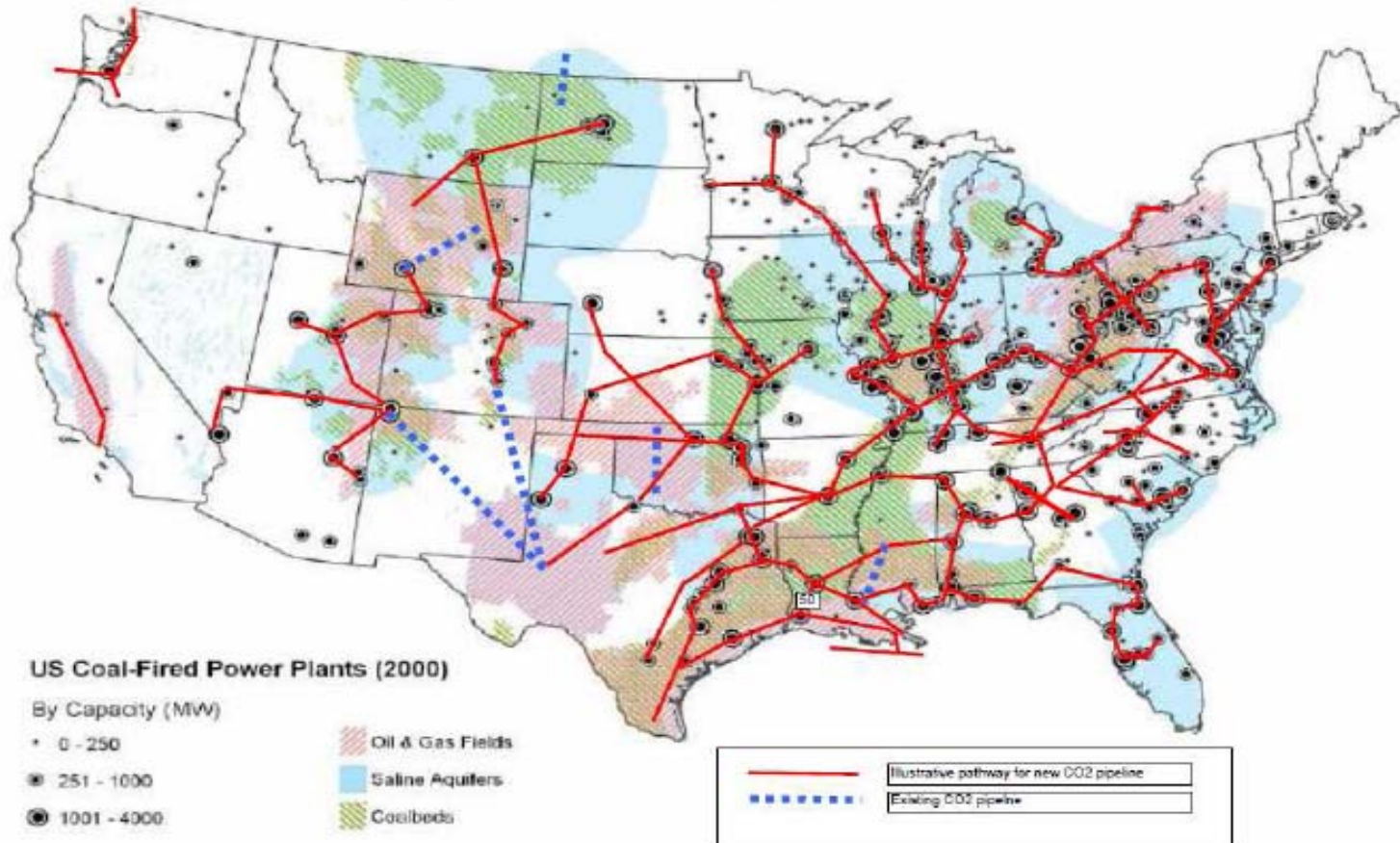
Current CO₂ Pipeline Network



INGAA High EOR CO₂ Pipelines

CARBON SEQUESTRATION & STORAGE: DEVELOPING A TRANSPORTATION INFRASTRUCTURE

Prepared for The INGAA Foundation, Inc. by: ICF International Feb 2009



States with Geologic Sequestration Legislation and Regulation

- Texas
- Wyoming
- Kansas
- New Mexico
- Oklahoma
- Montana
- Pennsylvania
- Indiana
- Kentucky
- New York
- Washington
- Louisiana
- Michigan
- Mississippi
- North Dakota
- South Dakota
- West Virginia
- Illinois

However

- While EOR demand for CO₂ will motivate early movers and infrastructure
- Depleted hydrocarbon reservoirs and brine aquifers will ultimately be the targets for permanent and larger sequestration efforts
- Climate legislation and carbon management requirements would determine the ultimate development of the depleted hydrocarbon and brine reservoirs
- Who pays-who benefits-and how?

What Does this Mean?

- Carbon legislation could push CO₂ towards mature oil fields in states with favorable regulations from inside and outside those states
- Compliance and monetary opportunity big drivers
- Traditional oil and gas producing states can value pore space, enhanced hydrocarbon production and create safe havens for their industries as a resource management issue not an environmental penalty
- Rules and regulations are being crafted to support CO₂-EOR-Sequestration now
- CO₂ Infrastructure requirements being explored and developed
- Long term stewardship/indemnification issues being addressed for sequestration
- Land use issues are looming on the horizon but again the issue is being worked on commercially and legally-natgas storage developers already know the process
- First movers will be motivated to push changes that favor their position

Conclusion

- US leads in expertise and experience
- Provides early carbon mitigation process
- Dollars spent/earned recycle back to state and national economies
- Sources of CO₂ immense but so are the sequestration options
- Engineering job spectrum broad: Mechanical, civil, environmental, materials, chemical and reservoir engineers
- Participants would be broad: Financiers, project developers, project owners, operators, subsurface service providers, land owners, water and mineral rights owners
- Human resources required in: Environmental, planning, regulatory, policy, research, legal, land, E&P, geology and training
- Material resource requirements huge: Capture technology, compression, pipe, valves, fittings, drilling rigs, monitoring equipment, software, support infrastructure, water processing, etc
- Active and depleted hydrocarbon reservoirs have new value proposition
- Brine aquifer resources become a valuable resource
- More domestic hydrocarbon production

Contact Information

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Additional Information

Natural Gas Storage Leases

- 2008 State of Alabama leased ~24,000 acres of state lands for ~\$124/acre plus ~\$0.025/mcf injection fee for 10 yrs plus four more 10 yr trances
- Specific geologic zones in three adjoining depleted natural gas fields
- Offshore waters-essentially unproven and undeveloped at time for natural gas storage
- First five years prepaid when lease was signed ~\$15 million

Texas's Interest In CO₂-EOR

www.rrc.state.tx.us/divisions/og/statistics/production/ogisopwc.html

www.unconventionalfuels.org/images/CO2EOR_Fact_Sheet.pdf

www.fossil.energy.gov/programs/oilgas/eor/index.html

- 1973 Texas Produced 3,444,000 bbl/d
- 2006 Texas Produced 934,000 bbl/day
- 2007 Texas By CO₂-EOR ~200,000 bbl/day
- National CO₂-EOR recoverables ~89 billion bbls-Texas ~30 billion
- Texas policy makers understand this and are driving legislation

H.R. 2454 Waxman Markey and also in Boxer-Kerry Bonus Allowances EPA Issue

- (3) BONUS ALLOWANCE VALUES.
- (D) For a carbon capture and sequestration project sequestering in *a geological formation for purposes of enhanced hydrocarbon recovery, the Administrator shall, by regulation, reduce the applicable bonus allowance value under this paragraph to reflect the lower net cost of the project* when compared to sequestration into geological formations solely for purposes of sequestration.

H.R. 2454 Waxman Markey and also in Boxer-Kerry Bonus Allowances EPA Issue

- CRITERIA FOR ESTABLISHING BONUS
- ALLOWANCE VALUES.—*In setting bonus allowance values under this paragraph, the Administrator shall seek to cover no more than the reasonable incremental capital and operating costs* of a project that are attributable to implementation of carbon capture, transportation, and sequestration technologies, taking into account
- (ii) *the reduced cost associated with sequestering in a geological formation for purposes of enhanced hydrocarbon recovery* when compared to sequestration into geological formations solely for purposes of sequestration;