WORKSHOP ON CALIFORNIA OPPORTUNITIES FOR CARBON CAPTURE, UTILIZATION & STORAGE
&
ENHANCED OIL RECOVERY: CHALLENGES & POLICY

"Carbon Capture, Utilization and Storage and Enhanced Oil Recovery (CCUS/EOR) Experience"

Michael E. Moore
Executive Director
North American Carbon Capture Storage Association

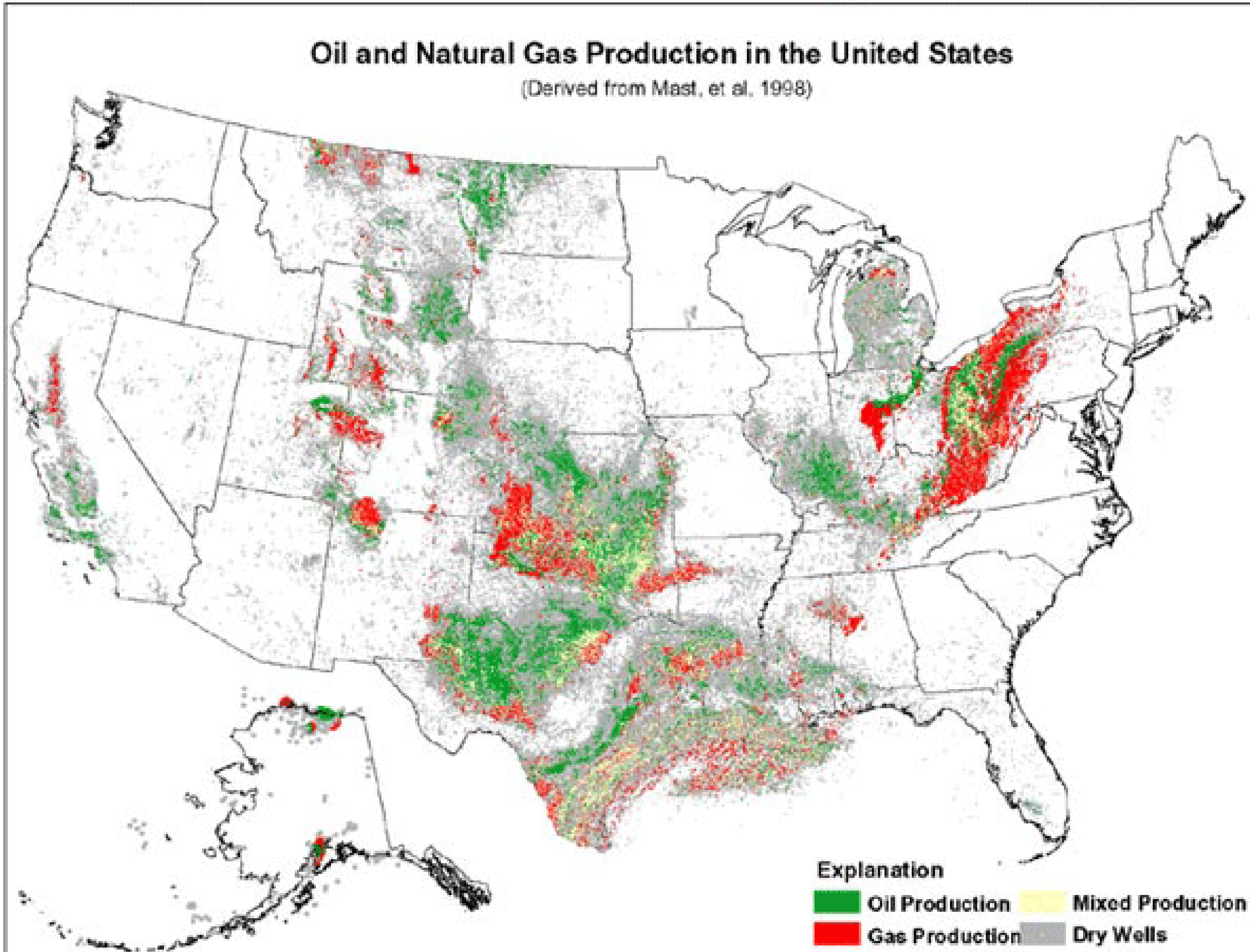
June 27th, 2012 Sacramento

NACCSA
North American Carbon Capture & Storage Association

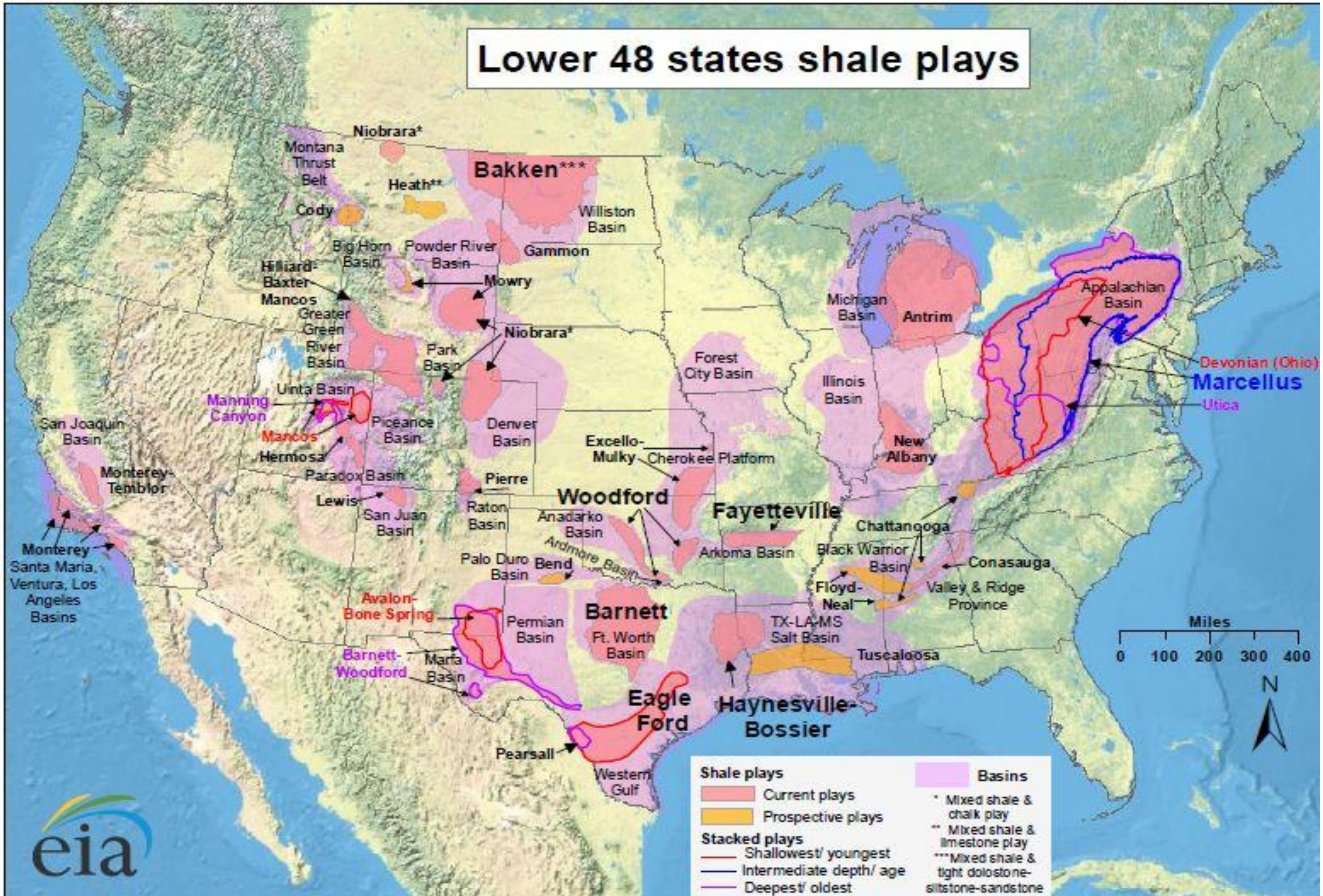
Overview

- DOE/NETL has done and supported extensive laboratory and field work, funded large scale projects and developed resources in conjunction with many diverse stakeholders.
- **States have decades of experience dealing with surface and subsurface issues of oil, gas, CO_2 and pipeline permitting, storage, pubic acceptance, handling land and mineral rights as well as right of ways.**
- Global efforts underway adding to the depth of technology, knowledge and experience.

US Conventional Oil and Gas Reservoirs

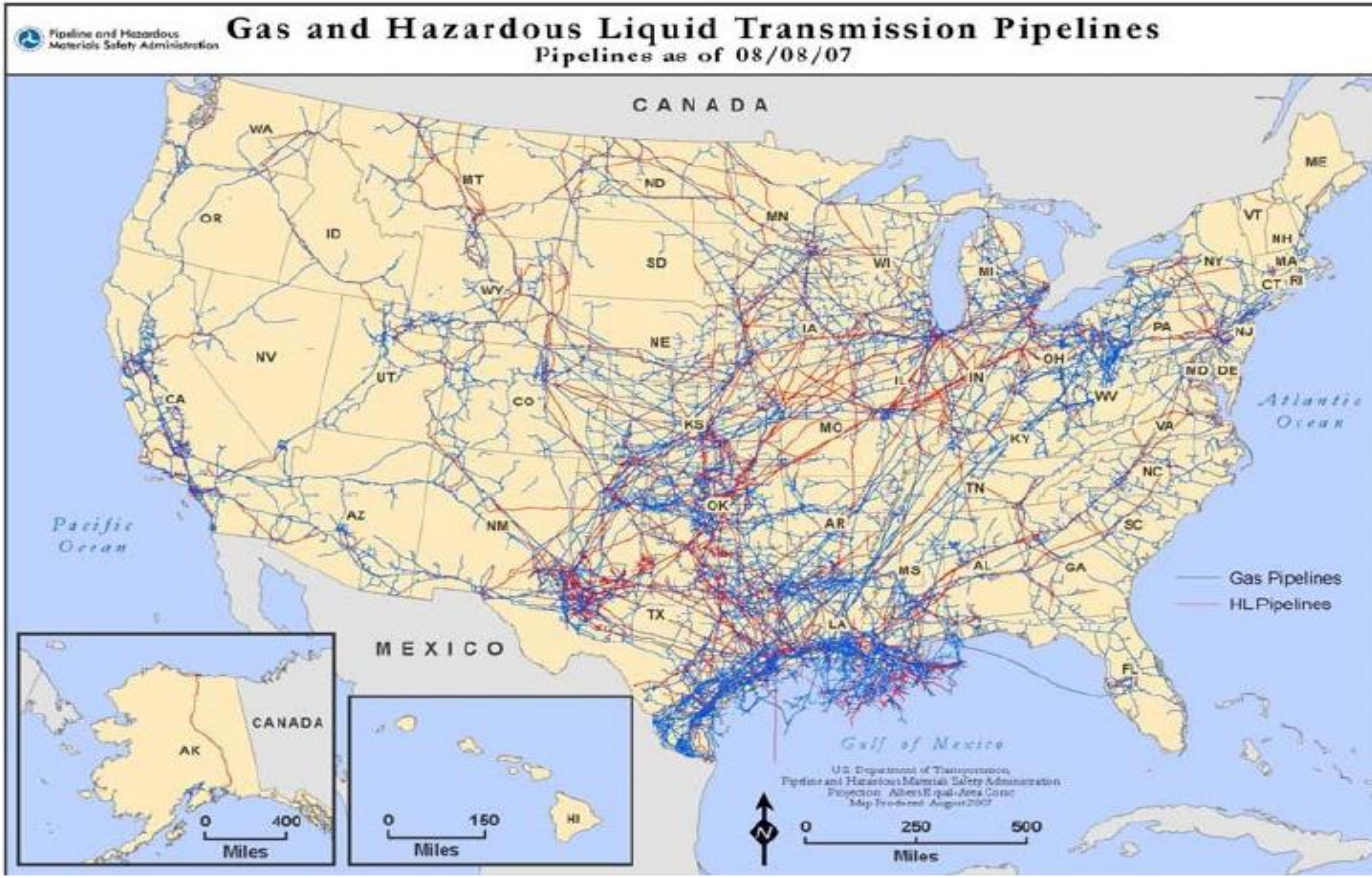


US Shale Plays- Unconventional Oil &Gas



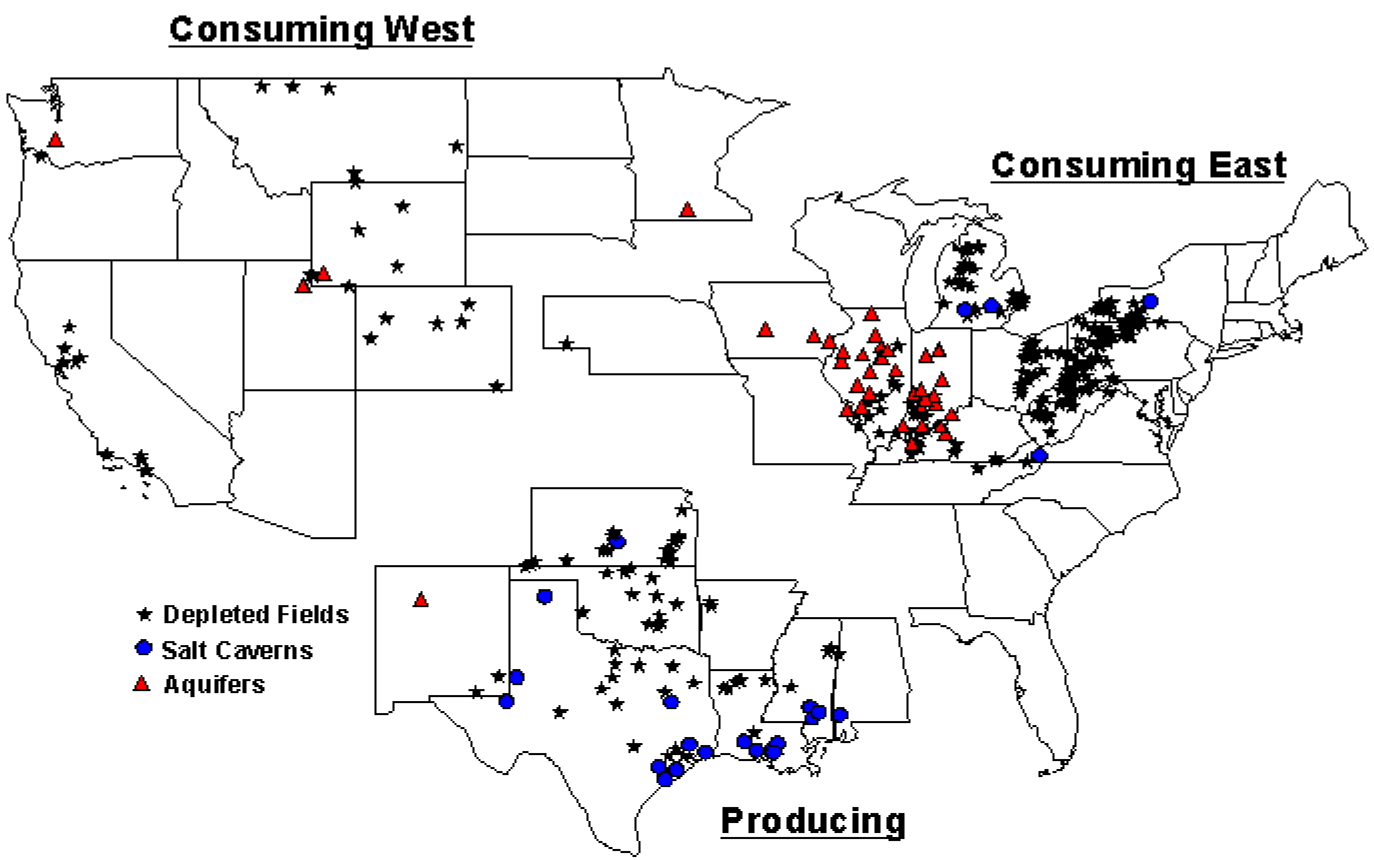
Source: Energy Information Administration based on data from various published studies.
Updated: May 9, 2011

480,000 Miles of Natgas - Oil and HL Pipelines-constantly expanding



US Natgas Storage ~4.2tcf at ~400 Sites

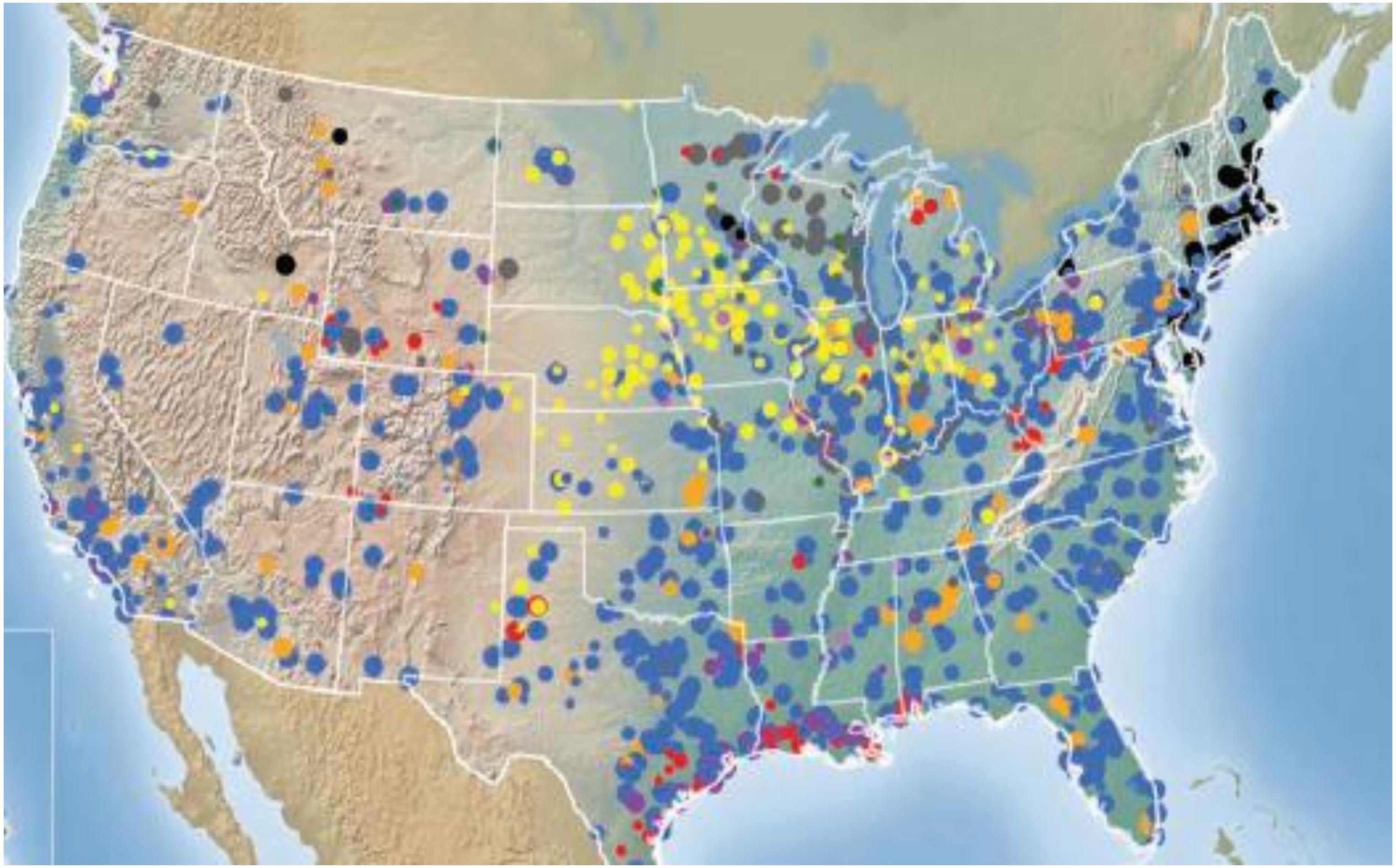
source: http://www.eia.gov/pub/oil_gas/natural_gas/analysis_publications/storagebasics/storagebasics.html



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

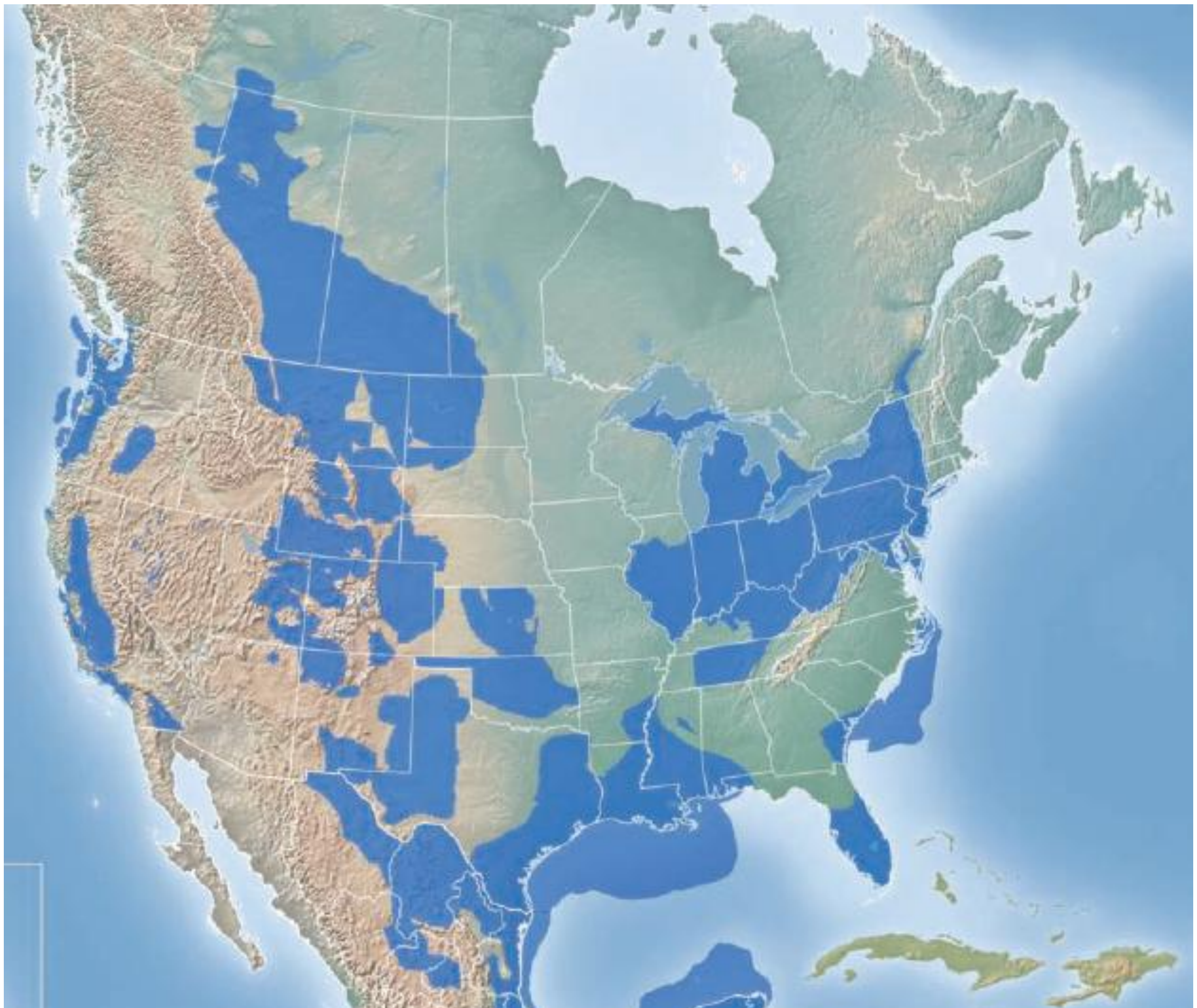
US Stationary CO_2 Sources

Source: http://www.netl.doe.gov/technologies/carbon_seq/refshelf/NACSA2012.pdf



North American Saline Reservoirs

Source: http://www.netl.doe.gov/technologies/carbon_seq/refshelf/NACSA2012.pdf



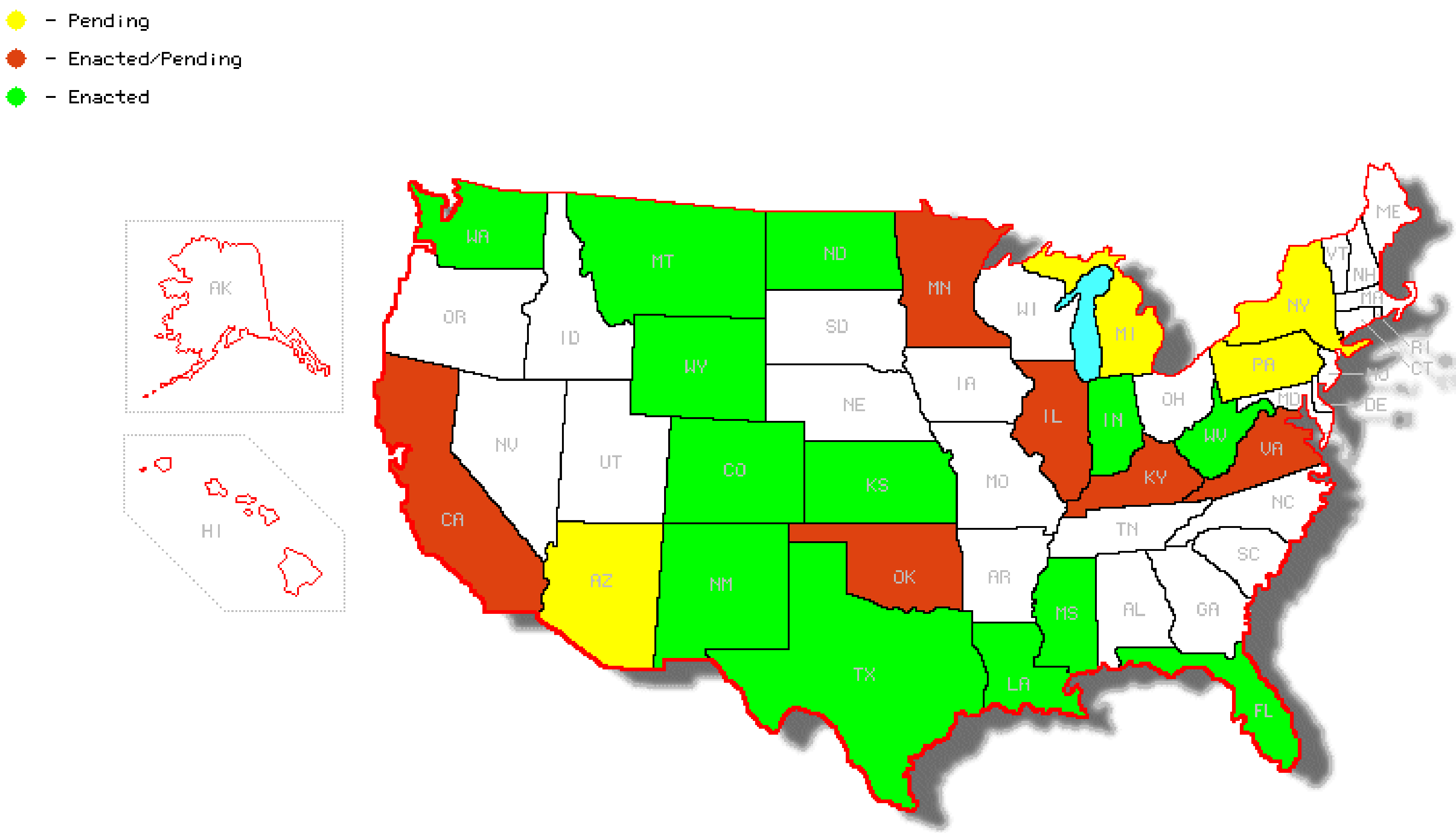
Considerations

- DOE/NETL has developed a series of "Best Practice Manuals".
- Interstate Oil and Gas Compact Commission (IOGCC) has developed model guidelines for states to use in geologic storage and infrastructure development for CO_2.
- Numerous studies and reports on risk valuation, subsurface rights, gas storage, geochemical and geo-mechanical issues, infrastructure, geographical issues of infrastructure and opportunities, public acceptance, future scenarios and economics.
- Many states have enacted legislation and regulations on CCUS development, CO_2 storage and pipelines.

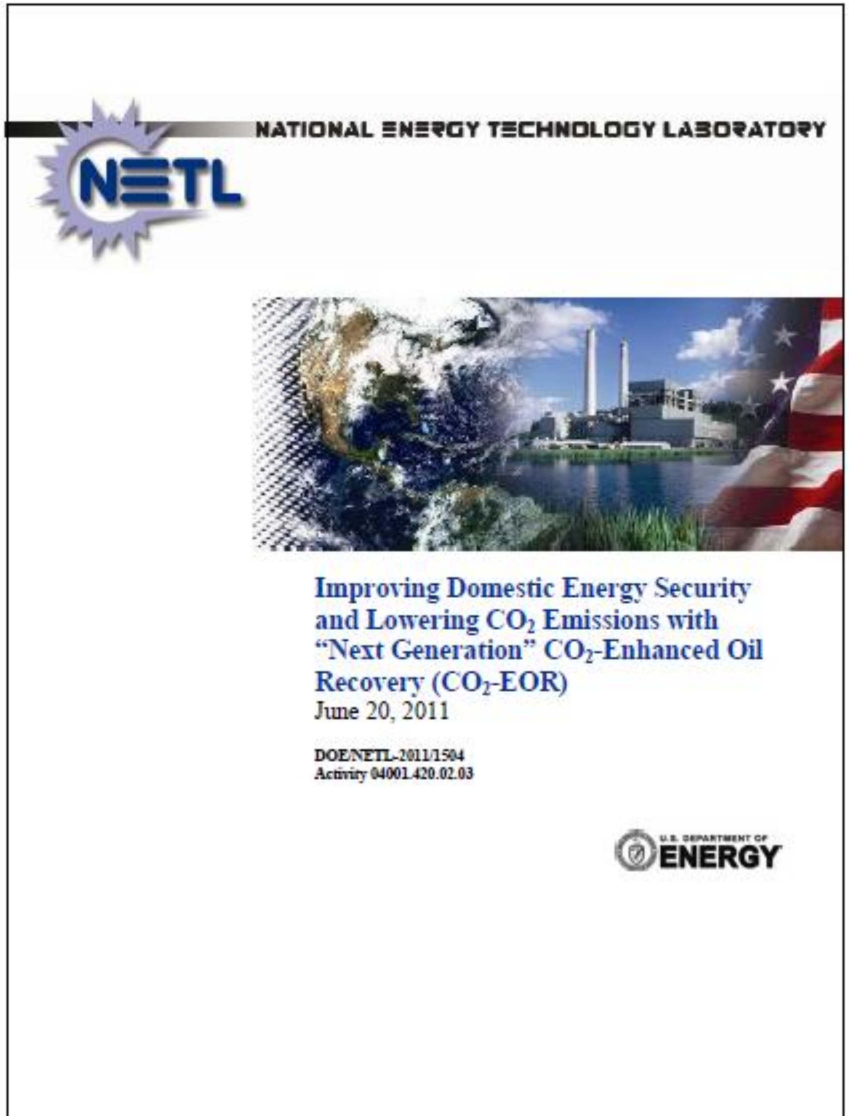

U.S. POLICY
CARBON DIOXIDE ENHANCED OIL RECOVERY: A CRITICAL DOMESTIC ENERGY, ECONOMIC, AND ENVIRONMENTAL OPPORTUNITY
National Enhanced Oil Recovery Initiative
C2ES CENTER FOR CLIMATE AND ENERGY SOLUTIONS
Great Plains Institute
February 2012
IEc
Valuation of Potential Risks Arising from a Model, Commercial-Scale CCS Project Site
Prepared for:
CCS Valuation Project Sponsor Group
Prepared by:
Chiara Trabucchi
Michael Donlan
Michael Huguenin
Matthew Konopka
Sarah Bolthrunis
Industrial Economics, Incorporated
2067 Massachusetts Avenue
Cambridge, MA 02140 USA
T: 617/354-0074
www.indecon.com
June 2012
SUPPORTED BY
GLOBAL CCS INSTITUTE
INDUSTRIAL ECONOMICS, INCORPORATED
A Policy, Legal, and Regulatory Evaluation
of the Feasibility of a National Pipeline Infrastructure for the Transport and Storage of Carbon Dioxide
Oil & Gas
NETL
the ENERGY lab
BEST PRACTICES for:
Carbon Storage Systems and Well Management Activities
April 2012
NATIONAL ENERGY TECHNOLOGY LABORATORY
U.S. DEPARTMENT OF ENERGY

States with CCUS Legislation

Source: http://www.sseb.org/files/ccs-legislation-full-version.pdf

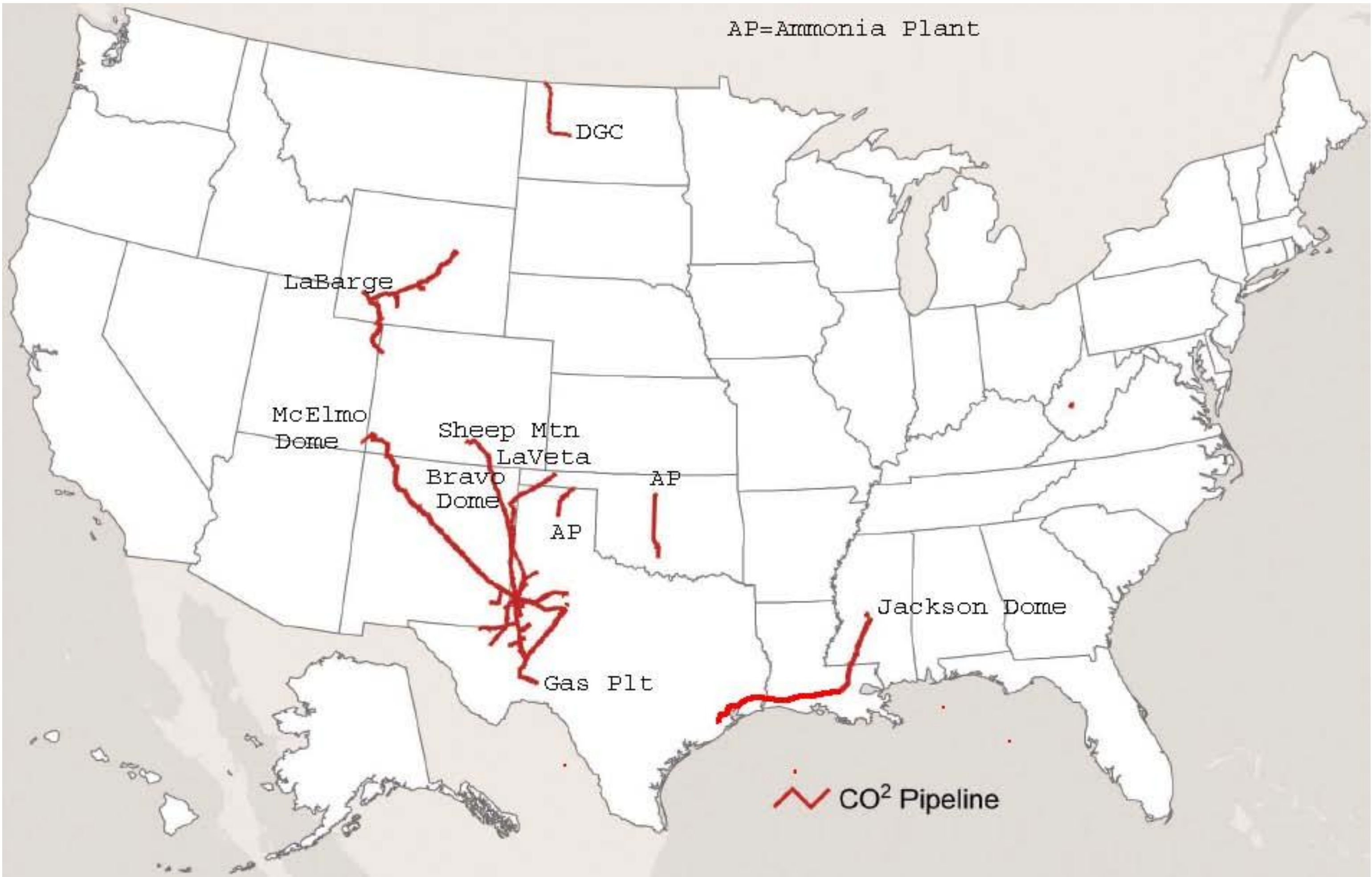


Supporting DOE/ARI CO_2-EOR Study



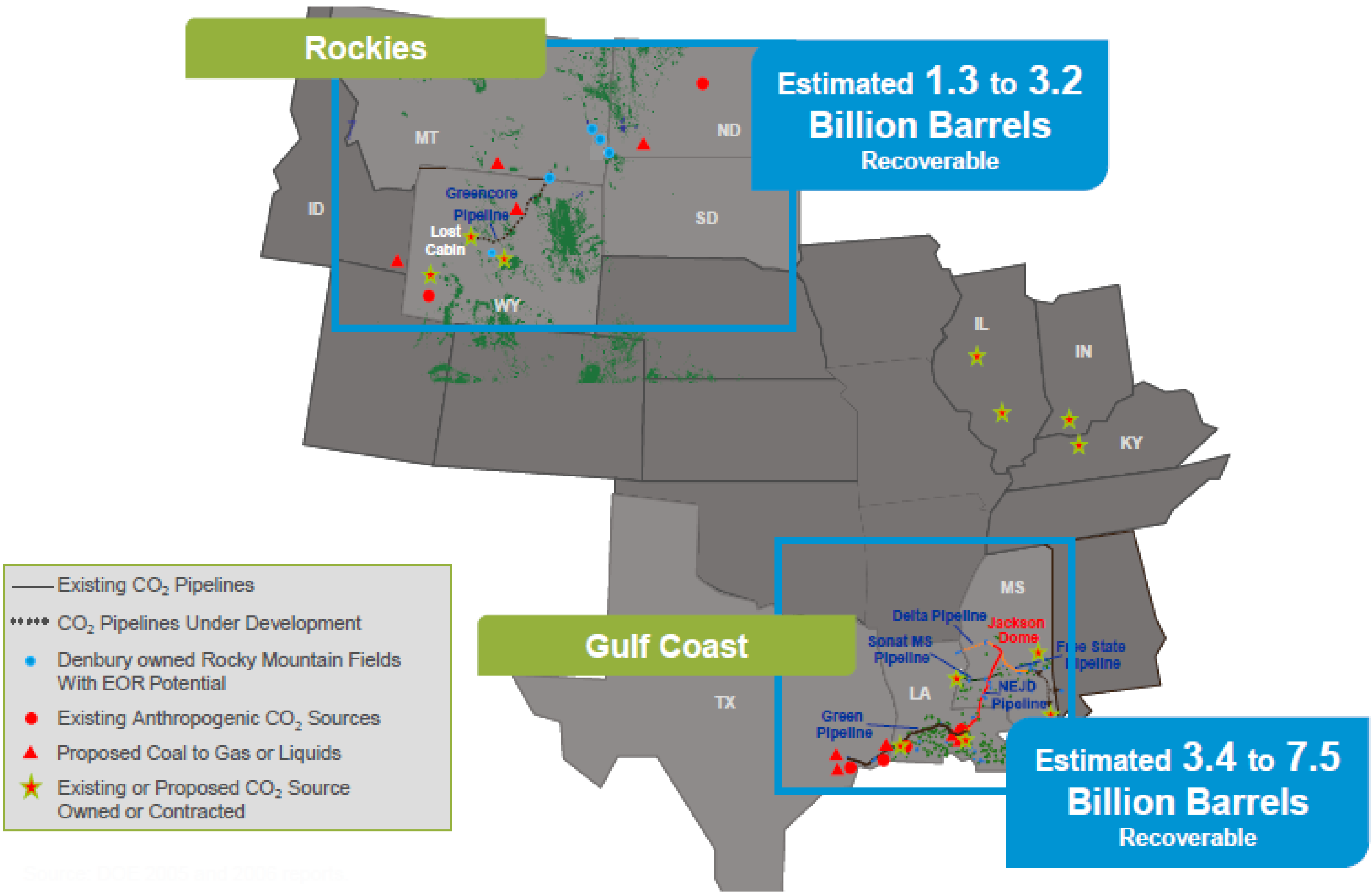
http://www.netl.doe.gov/energy-analyses/pubs/storing%20co2%20w%20eor_final.pdf

Existing CO_2 Transport Infrastructure



Denbury's Focus

Source: Denbury presentation CO2 Workshop Houston 12-2011



Scope of CO_2-EOR Potential

Reservoir Setting	Oil Recovery** (Billion Barrels)		CO_2 Demand/Storage** (Million Metric Tons)	
	Technical	Economic*	Technical	Economic*
1. Miscible CO_2-EOR				
Lower-48 Onshore	104.4	60.3	32,250	17,230
Alaska	8.8	5.7	4,110	2,330
Offshore	6.0	0.9	1,770	260
Sub-Total	119.1	67.0	38,130	19,820
2. Near Miscible CO_2-EOR	1.2	0.2	800	110
3. Residual Oil Zone***	16.3	n/a	6,500	n/a
TOTAL	136.6	67.2	45,430	19,930

*At $85 per barrel oil price and $40 per metric ton of CO_2 market price with ROR of 20% (before tax).

JAF2011_030.XLS

**Includes 2.6 billion barrels already produced or being developed with miscible CO_2-EOR and 2,300 million metric tons of CO_2 from natural sources and gas processing plants.

***ROZ resources below existing oil fields in three basins; economics of ROZ resources were beyond study scope.

Source: http://www.netl.doe.gov/energy-analyses/pubs/storing%20co2%20w%20eor_final.pdf

Distribution of Economic Value of Incremental Oil Production from CO_2-EOR

Source: http://www.netl.doe.gov/energy-analyses/pubs/storing%20co2%20w%20eor_final.pdf

Notes		Oil Industry	Private Minerals	Federal/ State	Power Plant/Other	U.S. Economy
1	**Domestic Oil Price ($/B)**	**$85.00**				
2	Less: Royalties	($14.90)	$12.40	$2.50		
3	Production Taxes	($3.50)	($0.60)	$4.10		
4	CO2 Purchase Costs	($12.00)			$10.80	$1.20
5	CO2 Recycle Costs	($9.60)				$9.60
6	O&M/G&A Costs	($9.00)				$9.00
7	CAPEX	($6.00)				$6.00
	Total Costs	**($55.00)**			-	
	Net Cash Margin	**$30.00**	**$11.80**	**$6.60**	**$10.80**	**$25.80**
8	**Income Taxes**	**($10.50)**	**($4.10)**	**$14.60**	**?**	**?**
	Net Income ($/B)	**$19.50**	**$7.70**	**$21.20**	-	

JAF2011_030.XLS

1 Assumes $85 per barrel of oil.

2 Royalties are 17.5%; 1 of 6 barrels produced are from federal and state lands.

3 Production and ad valorem taxes of 5%, from FRS data.

4 CO_2 market price of $40/tonne, including transport; 0.3 tonne of purchased CO_2 per barrel of oil; CCS would provide about 90% of CO_2 demand.

5 CO_2 recycle cost of $16/tonne; 0.6 tonnes of recycled CO_2 per barrel of oil.

6 O&M/G&A costs from ARI CO_2-EOR cost models.

7 CAPEX from ARI CO_2-EOR cost models.

8 Combined Federal and state income taxes of 35%, from FRS data.

Accelerating the Application of CO_2 Storage

Source: http://www.netl.doe.gov/energy-analyses/pubs/storing%20co2%20w%20eor_final.pdf

- Oil fields provide CO_2 storage options that can be permitted under existing (or slightly modified) regulatory guidelines, thereby avoiding the large delays inherent when waiting on new regulations and permitting for large-scale storage of CO_2 in saline formations.
- The pore space, mineral rights and long-term liability issues of oil fields are already well established and thus would not be impediments to an integrated CO_2 storage and CO_2-EOR project.
- Oil fields generally have existing subsurface data and often possess usable infrastructure such as injection wells and gathering systems, enabling more accurate assessment of CO_2 storage capacity and substantial cost savings.

Accelerating the Application of CO_2 Storage

Source: http://www.netl.doe.gov/energy-analyses/pubs/storing%20co2%20w%20eor_final.pdf

- Oil fields are located in areas with an accepted history of subsurface field activities contributing to public acceptance for storing CO_2.
- Second, oil fields provide an existing “brown field” storage site versus establishing a new “green field” site when preparing a saline formation for CO_2 storage.
- Third, the footprint of the CO_2 plume within an oil field would be several times smaller than within a saline formation.
- Finally, the early reliance on EOR for storing CO_2 would help build the regional pipeline infrastructure for future CO_2 storage projects in saline formations.

Current Developments/Drivers

- CCUS Methodology Released January 2012 by C2ES
- NEORI – February 2012, Phase I work done on incentives for CCUS/CO_2-EOR-Phase II underway
- NRAP – Developing subsurface technical "playbook"
- 45(Q) modifications efforts underway has prompted numerous studies on size and scope of EOR opportunity from industrial sources
- MWGA with the Clinton Initiative – developing action plan for CO_2 infrastructure and opportunity in the mid-central states
- DOE's shift from CCS to CCUS, making CO_2-EOR-Storage a supported/preferred pathway
- Crude oil (WTI) pricing now in the \$75-\$110/bbl range
- ROZ is creating strong interest in large volume/long term CO_2 sources
- Formation of the Gulf Coast CO_2-EOR Initiative-June 4th, 2012

Questions & Thank You!

Michael E. Moore

- **VP External Affairs and Business Development CCS**
- **Blue Strategies LLC**
- **WWW.BLUESOURCE.COM**

- **Executive Director and Founding Board of Directors Member**
- **North American Carbon Capture Storage Association**
- **WWW.NACCSA.Org**

- **VP and Founding Board of Directors Member**
- **Texas Carbon Capture Storage Association**
- **WWW.TXCCSA.Org**

- mmoore@bluesource.com

- Tel: 281-668-8475

Blue Strategies

NACCSA
North American Carbon Capture & Storage Association

Revenues Derived from CO_2-EOR

Source: http://www.netl.doe.gov/energy-analyses/pubs/storing%20co2%20w%20eor_final.pdf

- An important revenue stream accrues to the capturers of CO_2 emissions, helping lower the overall cost of conducting CCUS. In this report, we assume a price for CO_2 of $40/metric ton, delivered to the oil field at pressure. At 0.3 metric tons of purchased (net) CO_2 per barrel of recovered oil, this results in a transfer of $12 of the $85 per barrel oil to entities selling the CO_2 to the oil industry. Power and other industries involved with CO_2 capture would need to provide nearly 90% of the future CO_2 demand, gaining $730 billion dollars of revenues.

Revenues Derived from CO_2-EOR

Source: http://www.netl.doe.gov/energy-analyses/pubs/storing%20co2%20w%20eor_final.pdf

- A second revenue stream accrues to local and state governments and the Federal Treasury from royalties, severance and ad valorem taxes and income taxes. Our analysis shows that, at an oil price of $85 per barrel, $21.20 of this oil price is transferred directly to state and local governments and the Federal Treasury.
- With 67.2 billion barrels of economically recoverable oil from applying “Next Generation” CO_2-EOR, this equals $1,420 billion of revenues transferred to domestic public treasuries rather than to foreign treasuries.
- These revenues, in states such as Texas, Wyoming and others, are a primary source of funds for school systems and other valuable public services.

Revenues Derived from CO_2-EOR

Source: http://www.netl.doe.gov/energy-analyses/pubs/storing%20co2%20w%20eor_final.pdf

- A third revenue stream accrues to the general domestic economy from successful application of CO_2-EOR technology. With $25.80 of the $85 barrel oil price being spent on domestic wages and purchases, this provides $1.7 trillion dollars of gross revenues to the domestic economy.

Revenues Derived from CO_2-EOR

Source: http://www.netl.doe.gov/energy-analyses/pubs/storing%20co2%20w%20eor_final.pdf

- A fourth revenue stream accrues to a variety of entities holding private mineral rights from royalty payments ($7.70 per barrel) and to the U.S. oil industry ($19.50 per barrel) for return of and return on capital investment.
- The Texas economic model shows that every dollar of direct investment in oil development has a multiplier of 4 in terms of supporting economic activity.

Potential Future CO_2 Infrastructure

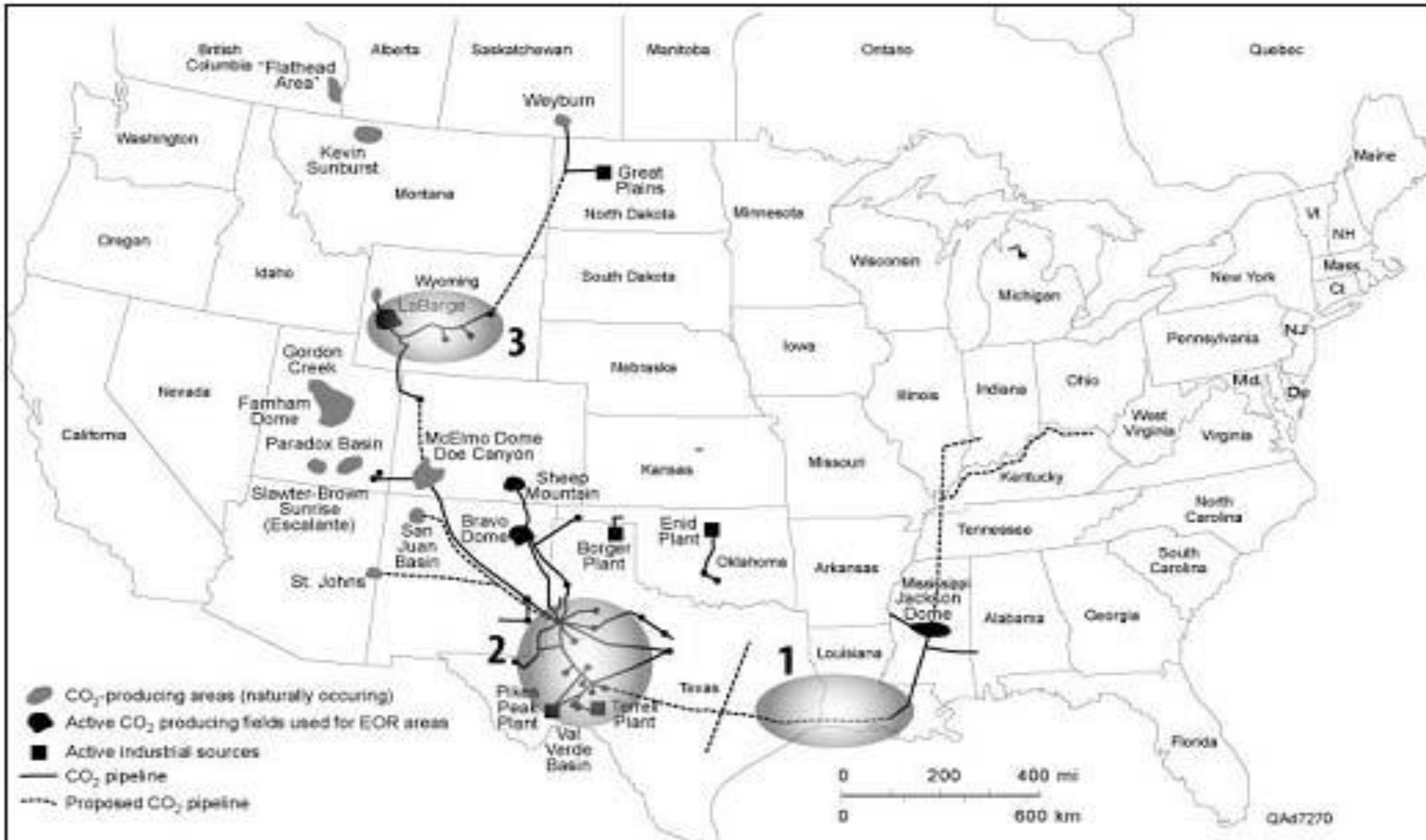


Fig 2: A Framework Depiction of a Natonal CO2 Pipeline Network ("The Horseshoe"). The Shaded ellipses Represent Three Areas Where Very Large EOR/CCS Projects are Active or Proposed

Proposed Wyoming CO_2 Pipeline Corridor

- **Governor Matt Mead Looks to Support CO_2 Pipeline Network May 2012**
- CHEYENNE, Wyo. – As part of his energy strategy, Governor Matt Mead is opening a discussion about a proposed statewide network of carbon dioxide (CO_2) pipeline corridors within federal land boundaries. Establishing pre-approved corridors would protect open spaces and minimize environmental impacts. Such corridors are intended to significantly shorten permitting time for future pipeline projects, which in turn would allow for enhanced oil recovery.
- "There is currently no consistent, statewide plan for CO_2 pipelines," Governor Mead said. Presently, pipeline corridors on federal land are separately determined by the nine individual Bureau of Land Management offices in Wyoming. "This is a piecemeal approach and we can benefit the diverse interests across the state by providing instead a cohesive approach. A well thought out and laid out statewide network could serve as a model for other projects and as an economic tool for Wyoming." Capture and storage of CO_2 have the potential to advance energy technology and improve air quality. CO_2 flooding is also a proven method of enhanced oil recovery.
- Governor Mead plans to work on proposed corridors with the Bureau of Land Management. Any proposal would be reviewed and open to public comment, possibly becoming a Record of Decision to update each Resource Management Plan of the various BLM offices across Wyoming.
- The state would like the BLM offices to coordinate to identify a cohesive, statewide corridor, and the Wyoming Legislature recently granted its approval of the plan. The state began formal discussions on the topic May 15th.
- The state is especially interested in developing EOR in the Bighorn and Powder River basins, said Brian Jeffries, executive director of the Wyoming Pipeline Authority.
- A preapproved corridor would make permitting easy, he said, rather than having operators get permits on a project-by-project basis.
- Much of the permitting would fall to the Bureau of Land Management because the federal government owns about 70 percent of the land in Wyoming. Ten BLM field offices oversee the state, and each generates a 20-year resource management plan for its jurisdiction. Two field offices began working on new plans in the past year, and neither included enhanced oil recovery as a possible land use, Rob Hurless said, energy strategy adviser to Gov. Mead

Statement from John Thompson, Director, Fossil Transition Project, on opinion paper

Source: www.catf.us/newsroom/releases/2012/20120619-CATF_statement_on_Zoback_paper_on_seismic_risk_from_geologic_CO2_storage.pdf

- Statement from John Thompson, Director, Fossil Transition Project, on opinion paper by Dr. Mark Zoback et al. on seismic risk of geologic storage of carbon dioxide, June 19, 2012
- Dr. Zoback's opinion article released yesterday seeks to cast doubt on the overall viability of geologic carbon storage, based on concerns over induced seismicity. In the four-page "Perspective" piece, he highlights the importance of ensuring that seismicity is considered in the siting, permitting and managing of carbon storage sites. However, Dr. Zoback has failed to fully take into account multiple options available for geologic carbon storage that, taken together, would indicate a more optimistic assessment of the long-term potential for CCS:
- · Already in the U.S., over 1 billion tons of CO2 have been safely injected and geologically trapped since the 1970s in depleted oil fields through enhanced oil recovery (EOR). The National Energy Technology Laboratory projects that the US could sequester at least 20 billion tons more CO2 for EOR projects, roughly 10 times the output of the U.S. coal fleet.
- · Even beneath the U.S. Midwest, where many of the region's coal-fired power plants will look to store their carbon emissions, Dr. Zoback acknowledges that some of the region's emissions can be safely stored in the Mt. Simon formation in the Illinois basin, where there are also several other target formations with multiple overlying seals that he does not even consider. And, if a maximum storage level is ever attained there, CO2 could be pipelined to other storage sites where there is minimal seismic risk. A pipeline to southern Illinois is already in the planning stages that will bring CO2 from the Midwest to EOR projects in LA, TX and MS.
- · Offshore, within the continental shelf, where Dr. Zoback acknowledges that formations would not be prone to seismicity, there is an enormous capacity on all three U.S. coastlines for carbon sequestration, with estimates ranging from 500 billion tons to 7.5 trillion tons, according to NETL.
- · To reduce pressure in some storage formations, brine water removal combined with saline storage can ease and redistribute pressures to further reduce seismic risk.
- · According to researchers at MIT who have studied the CO2 storage capacity
  in the U.S., there's just not enough data to construct any models that can currently predict earthquakes induced from carbon dioxide injections.
- · Carbon dioxide injection projects around the world have yet to report any significant induced seismicity (including the 1 billion tons injected for EOR).
- So while Dr. Zoback is raising the awareness of the importance of selecting safe sequestration sites, we strongly disagree with his pessimistic conclusion about the global future of carbon capture and storage. His opinion paper draws that conclusion by analogy and computer modeling, but it's highly premature to condemn CCS without more experience; more investment and research is needed, not less. There's no question that seismic factors must be considered in the planning and permitting process for selecting carbon storage sites, and that EPA and state regulators should pay attention to induced seismicity. But fundamentally, we maintain that the expense of overcoming any such obstacles will be minimal compared to the global costs of climate change from unmitigated industrial greenhouse gas emissions into our atmosphere.

NEORI CO_2-EOR Incentives Report

Source: http://neori.org/NEORI%20Methodology%20Brief.pdf

- The Center for Climate and Energy Solutions (C2ES) and the Great Plains Institute (GPI) conducted an analysis, with extensive input from the participants of National Enhanced Oil Recovery Initiative (NEORI), to inform NEORI's recommendations for a federal production tax credit to support enhanced oil recovery with carbon dioxide (CO_2-EOR). In particular, C2ES and GPI explored the implications of the recommendations for CO2 supply, oil production and federal revenue. This document describes the research, assumptions, and methodology used in the analysis.
- **NEORI's recommendations report, Carbon Dioxide Enhanced Oil Recovery: A Critical Domestic Energy, Economic, and Environmental Opportunity, can be found at: http://neori.org/publications/neori-report/.**

- C2ES and GPI compared the likely cost of a federal tax credit for greater CO_2 capture and supply with the federal revenues expected from applying existing tax rates to the resulting incremental oil production. C2ES and GPI quantified two key relationships for CO_2-EOR development and a related tax credit program:

- 1) Cost gap – the difference between CO_2 suppliers' cost to capture and transport CO_2 and EOR operators' willingness to pay for CO_2. The goal of the tax credit is to bridge the cost gap. Thus, the cost gap determines the expected level of the tax credit in a proposed competitive-bidding process.

- 2) Revenue neutrality/revenue-positive outcome the federal government will bear the cost of a CO_2-EOR tax credit program, yet it will enjoy increased revenues from the expansion of CO_2-EOR oil production when existing tax rates are applied to the additional production. C2ES and GPI analyzed when the net present value of expected revenues would equal or exceed the net present value of program costs.

- C2ES and GPI calculated the tax credit required to bridge the cost gap, and the cost and revenue implications. C2ES and GPI developed input assumptions based on real-world physical and market conditions after consulting with NEORI participants and other industry experts and reviewing available literature. C2ES and GPI developed a core scenario based on "best guess" inputs and conducted several sensitivity analyses of key inputs. C2ES and GPI demonstrated that a program can be designed that will become "revenue positive" (defined as when the federal revenues from additional new oil production exceed the cost of a carbon capture tax credit program after applying a discount rate to both costs and revenues) within ten years after tax credits are awarded. Sensitivity analysis reveals that the program remains revenue positive using a realistic range of likely assumptions