

CO₂-EOR

CCUS And The Fight Over Carbon Emissions



CO₂ Injection Well

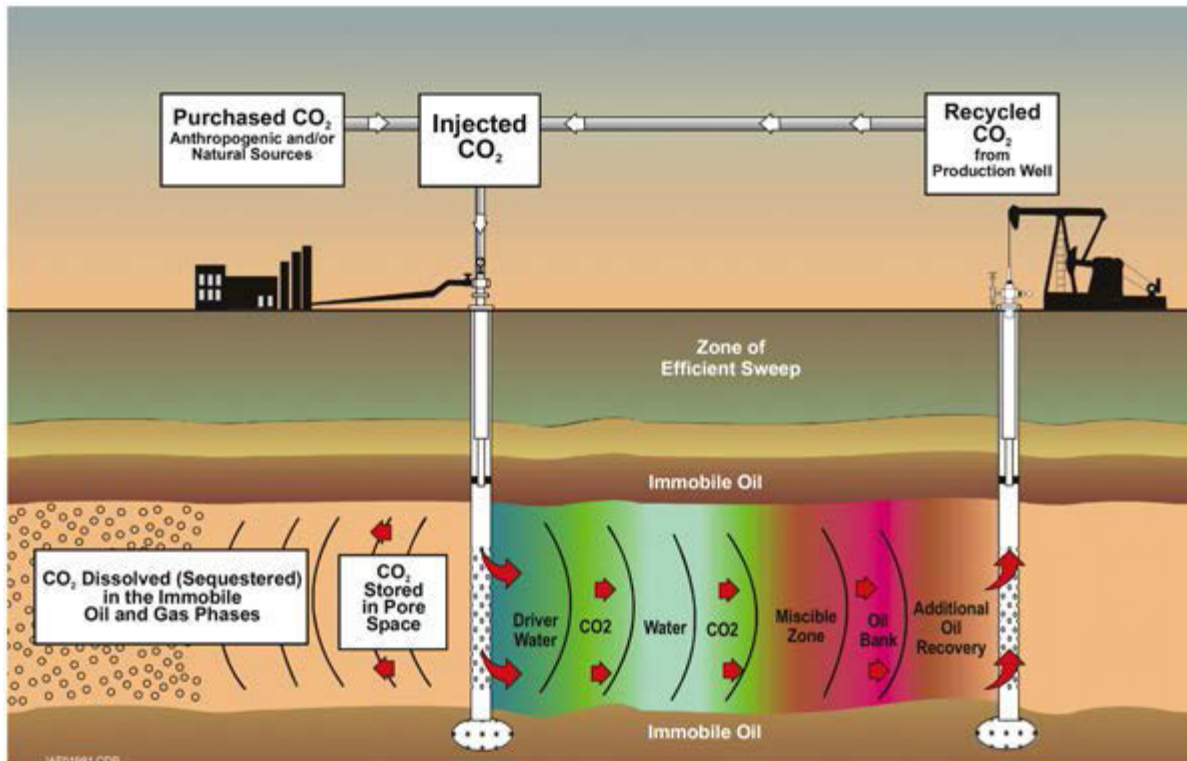
Presented to the American Action Forum

June 2014

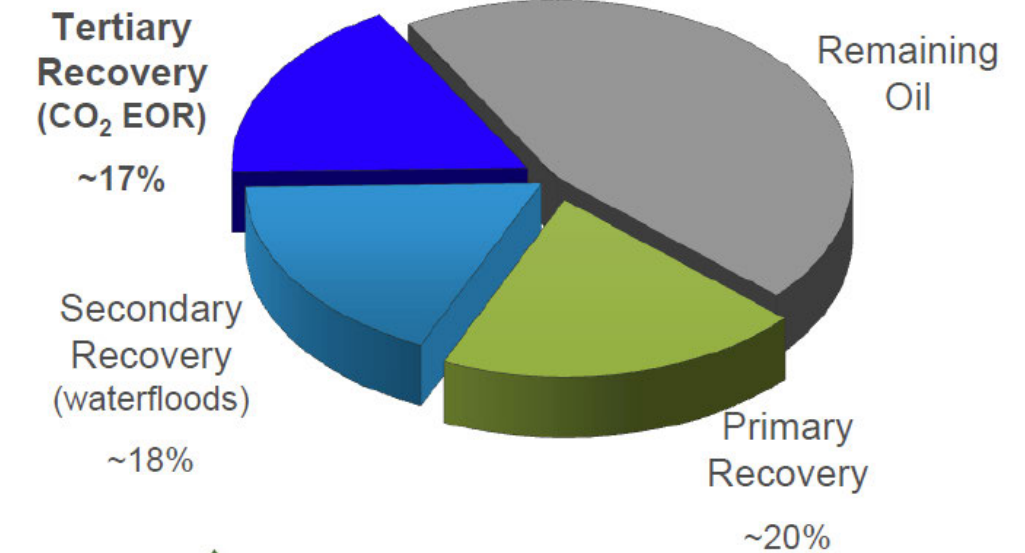
Edward Dodge

What is CO₂-EOR?

- **Injecting Carbon Dioxide for Enhanced Oil Recovery** is a proven method to sequester CO₂ and extend the productive life of oil fields.



CO₂ EOR Delivers Almost as Much Production as each of Primary and Secondary Recovery



Denbury 

Source: Advanced Resources International and Melzer Consulting, Optimization of CO₂ Storage in CO₂ Enhanced Oil Recovery Projects, prepared for UK Department of Energy & Climate Change, November 2010.

CO₂-EOR Pioneered in the USA

- Practiced since the 1970's.
- Currently ~4000 miles of CO₂ pipelines and over 100 projects.
- Injecting 60 million metric tons of CO₂ annually.
- Producing 300,000 barrels of oil per day (6% of US oil production).
- Most of the CO₂ sourced from natural underground deposits.



Location of Current CO₂-EOR Projects and Pipeline Infrastructure

CO₂-EOR is a Rare Point of Agreement Between Environmental Groups and Fossil Fuel Producers



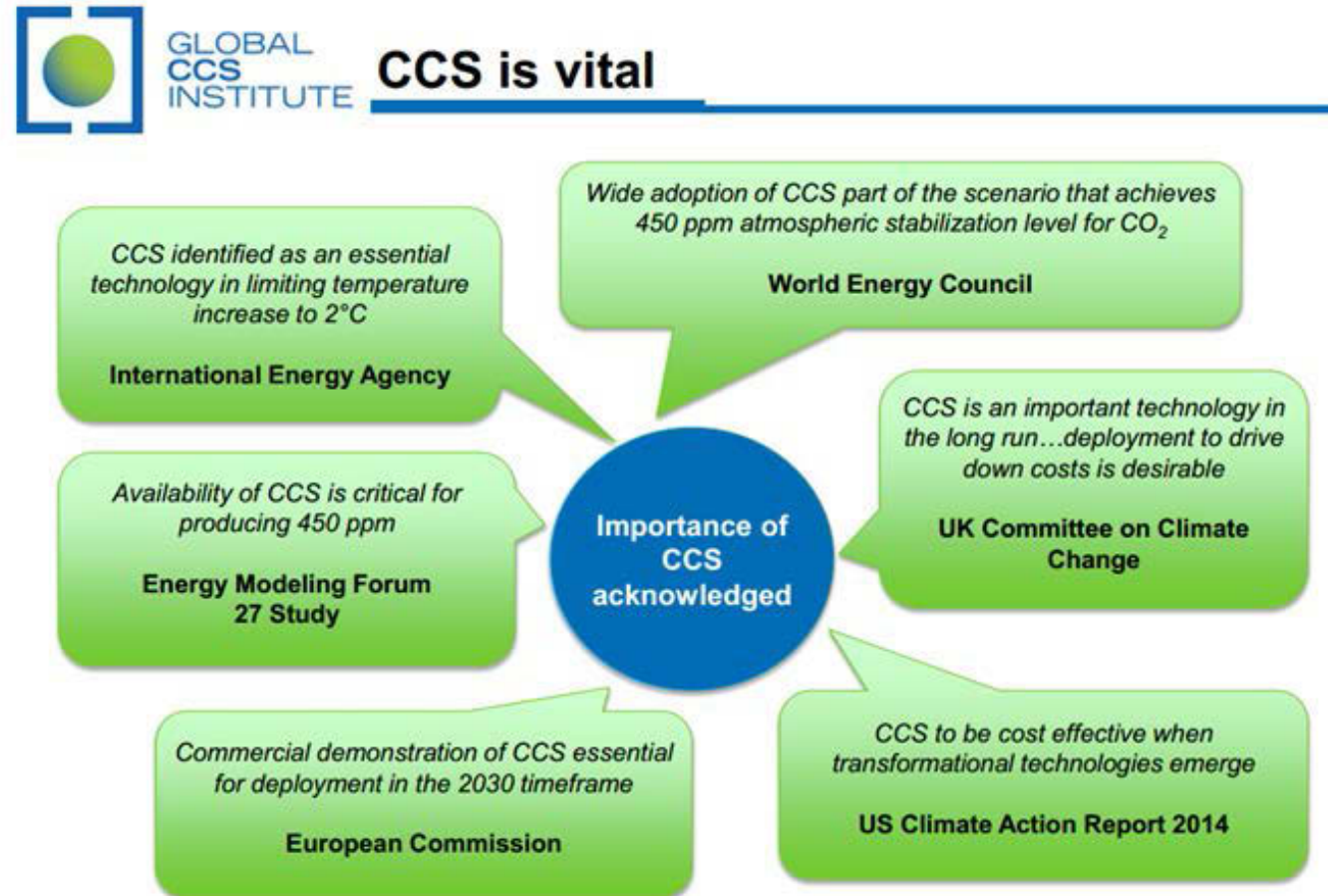
Tapping into Stranded Domestic Oil: Enhanced Oil Recovery with Carbon Dioxide Is a Win-Win-Win



NATIONAL PETROLEUM COUNCIL



CCS is Recognized Throughout the World as Crucial in the Fight Over Climate Change

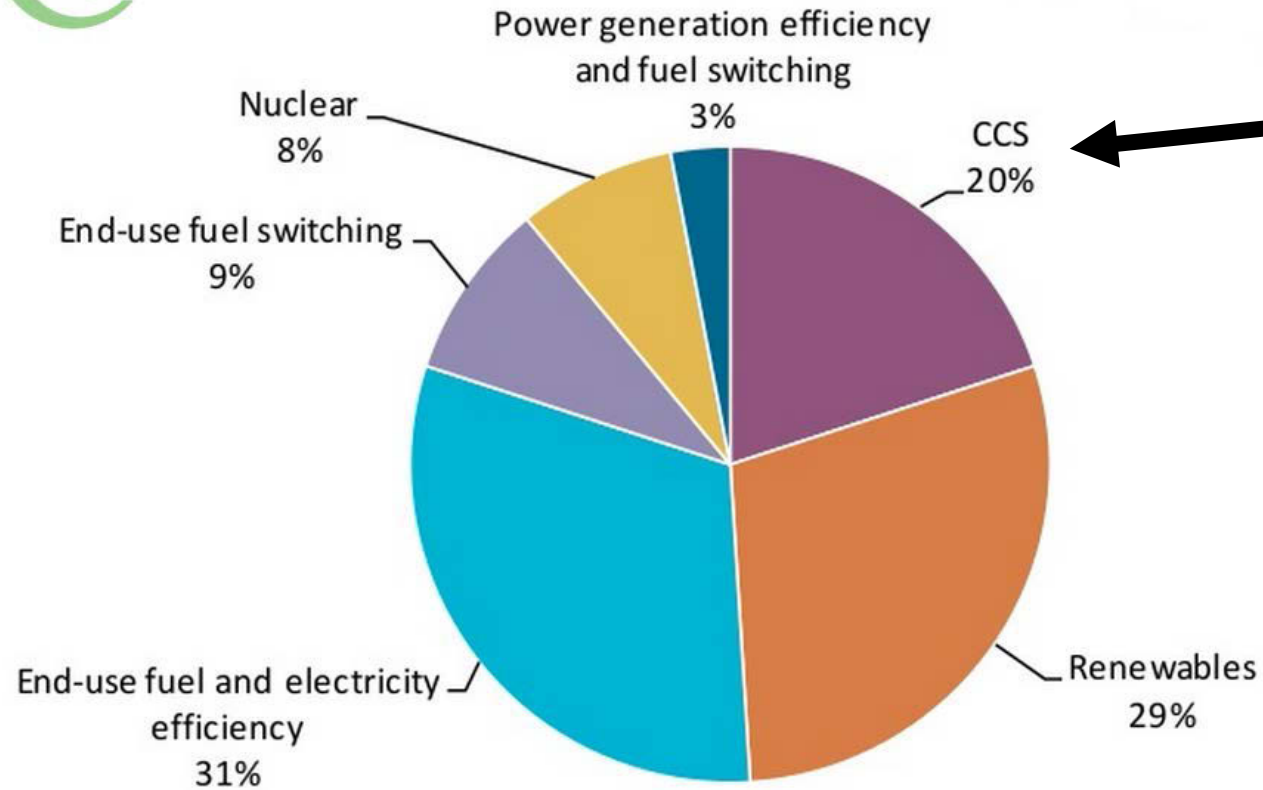


Strategies For Meeting Carbon Emissions Goals



International Energy Agency

Energy Technology Perspectives 2012



CCS is Critical

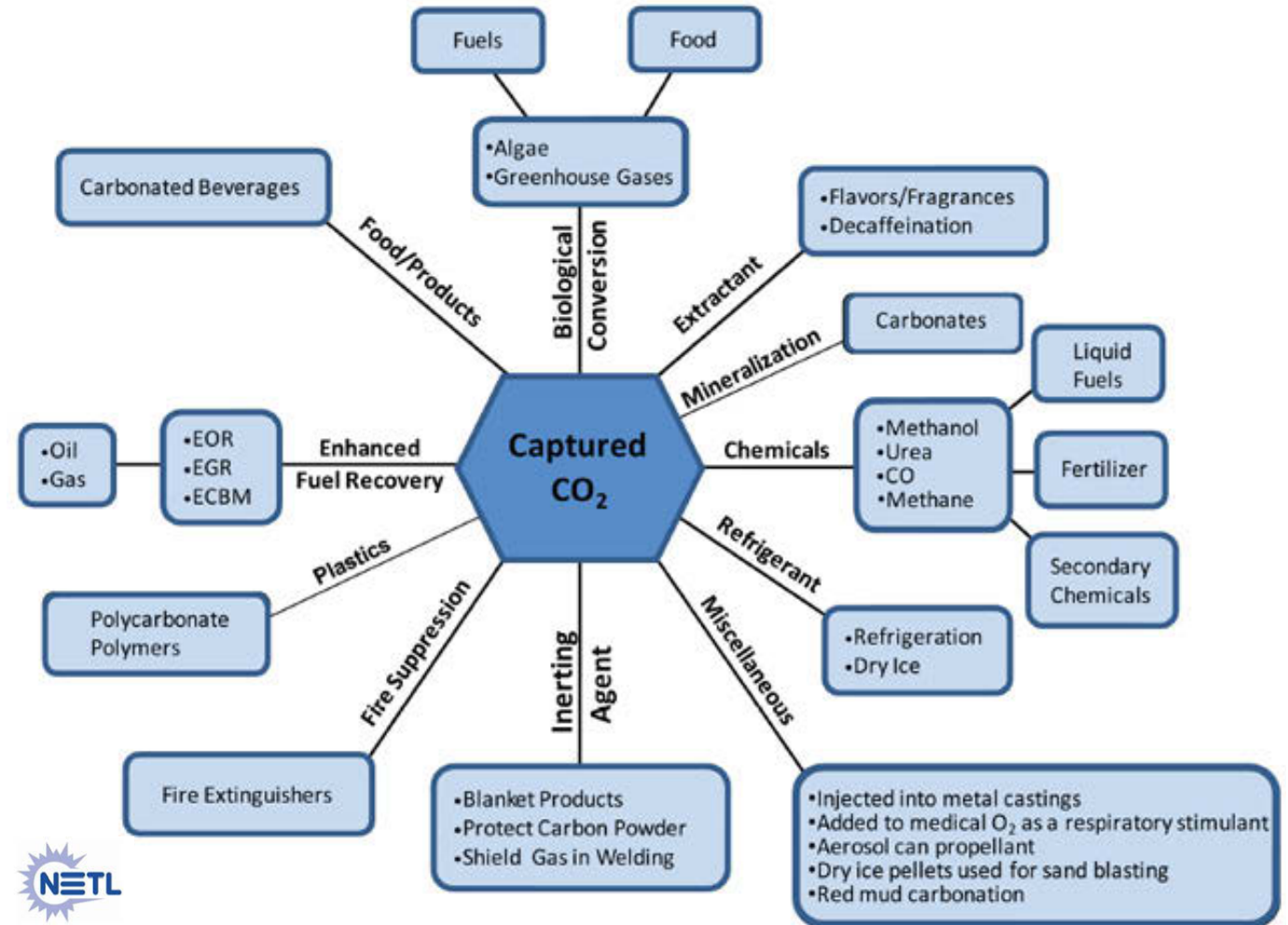


Carbon Utilization Converts CCS into CCUS

There are many uses for CO₂ but EOR is by far the largest.

CO₂ can be a valuable commodity rather than a waste product.

Utilization transforms the economic model for CCS.



The Resource Potential is Enormous

United States CO₂ EOR Resource Assessment

	Crude Oil Resource, Billion Barrels	CO ₂ Demand, Billion metric tons
Current CO ₂ EOR Technology Scenario, Economic reservoirs, lower 48 onshore*	24	9
Next Generation CO ₂ EOR, Economic reservoirs, lower 48 onshore*	60	17
Next Generation CO ₂ EOR, add reservoirs that are un-economic but technically possible, lower 48 onshore	104	33
Next Generation CO ₂ EOR, economic + technically possible, add residual oil zones, Alaska, and offshore Gulf of Mexico	137	45

* Economics based on 85 \$/bbl, \$40/mtCO₂, and 20% IRR before tax
Source: DOE/NETL 2011/1504

Billions of tons of CO₂ sequestered.

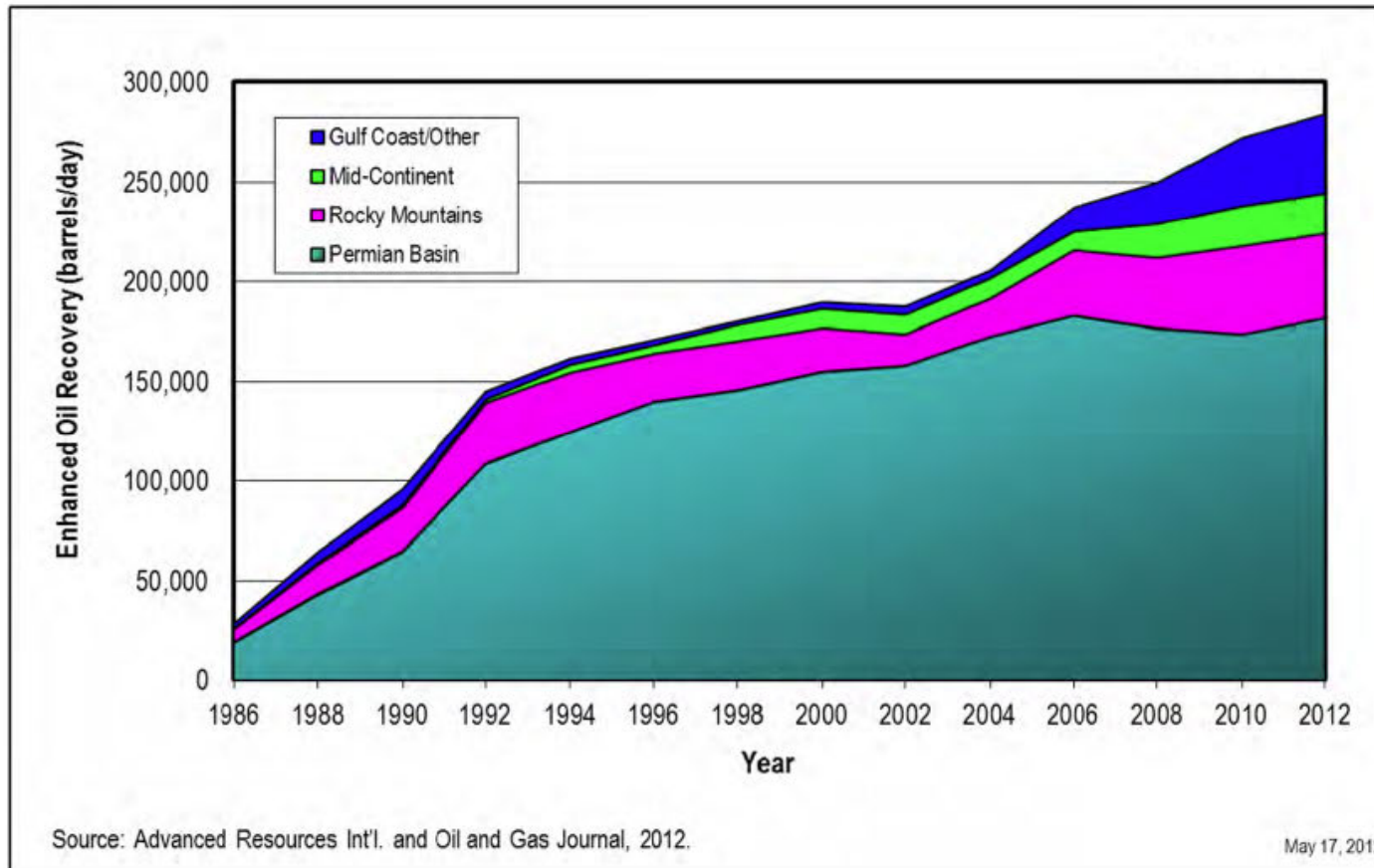
Billions of barrels of oil produced.

1 ton of CO₂ =>
~2.5 barrels of oil.



Crude Oil Production from CO₂-EOR

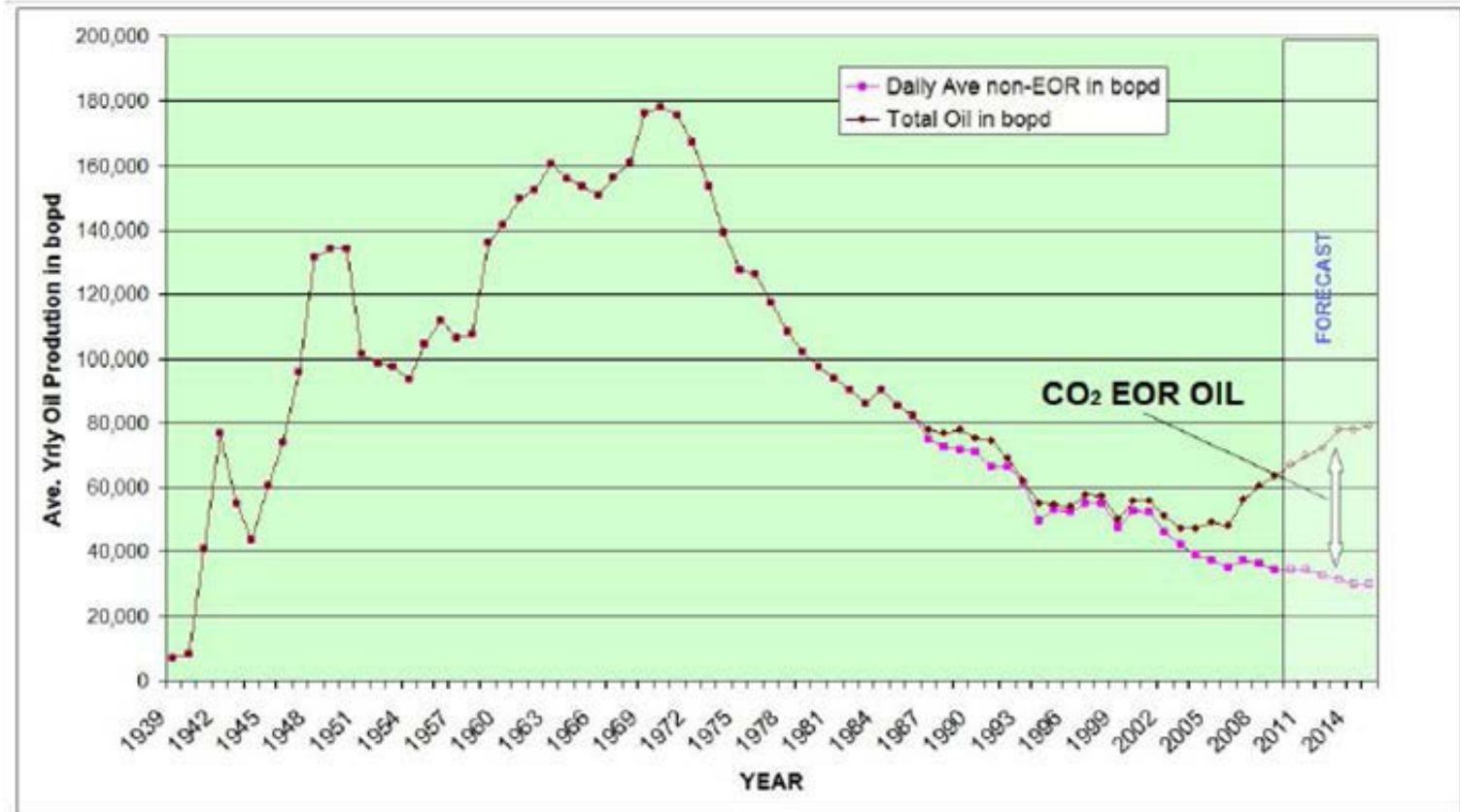
Oil production from CO₂-EOR has nearly doubled during the past 5 years.
In 2012, it represented 6% of total U.S. crude oil production.



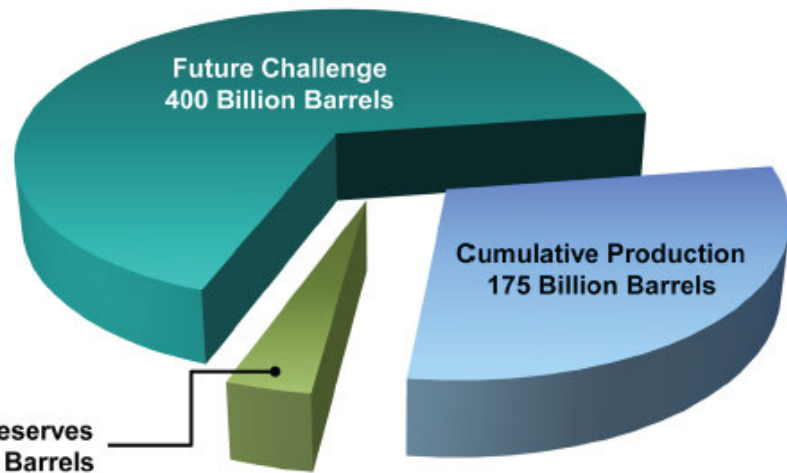
*Data is for EOR production rate at end of prior year; U.S. crude oil production of 6.02 MMB/D in 2012.
Source: Advanced Resources Int'l. and the Oil and Gas Journal, 2012.

CO₂-EOR Can Reverse Oil Production Declines

Mississippi Oil Production History and Short-Term Projections ("Violating the Hubbert Curve")



Original Oil in Place: 596 Billion Barrels*
 "Stranded" Oil in Place: 400 Billion Barrels*



*Excludes deepwater Gulf of Mexico
 Source: Advanced Resources Int'l. (2008)

CO₂-EOR Will Store Multiple Billion Metric Tons of Industrial CO₂

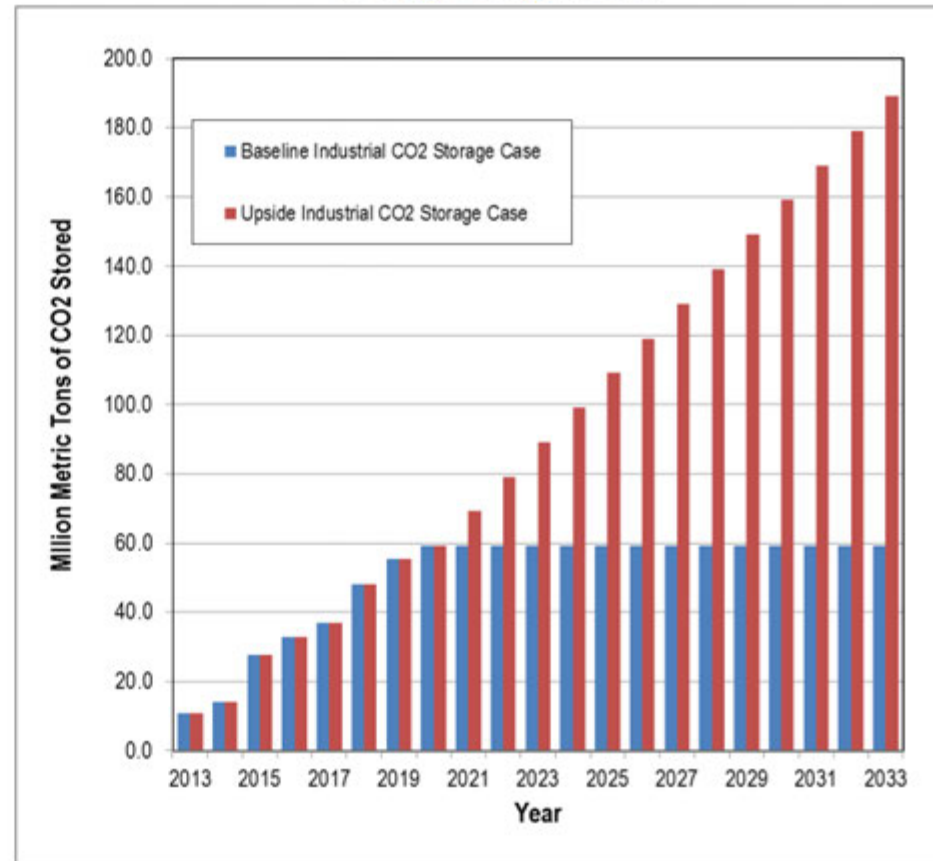
Even with no changes in greenhouse gas policies, CO₂-EOR is on pace to store one to two billion metric tons of industrial CO₂ by year 2030:

- Existing/announced CO₂-EOR projects will store one billion metric tons.
- New CO₂-EOR projects could add a second billion metric tons.

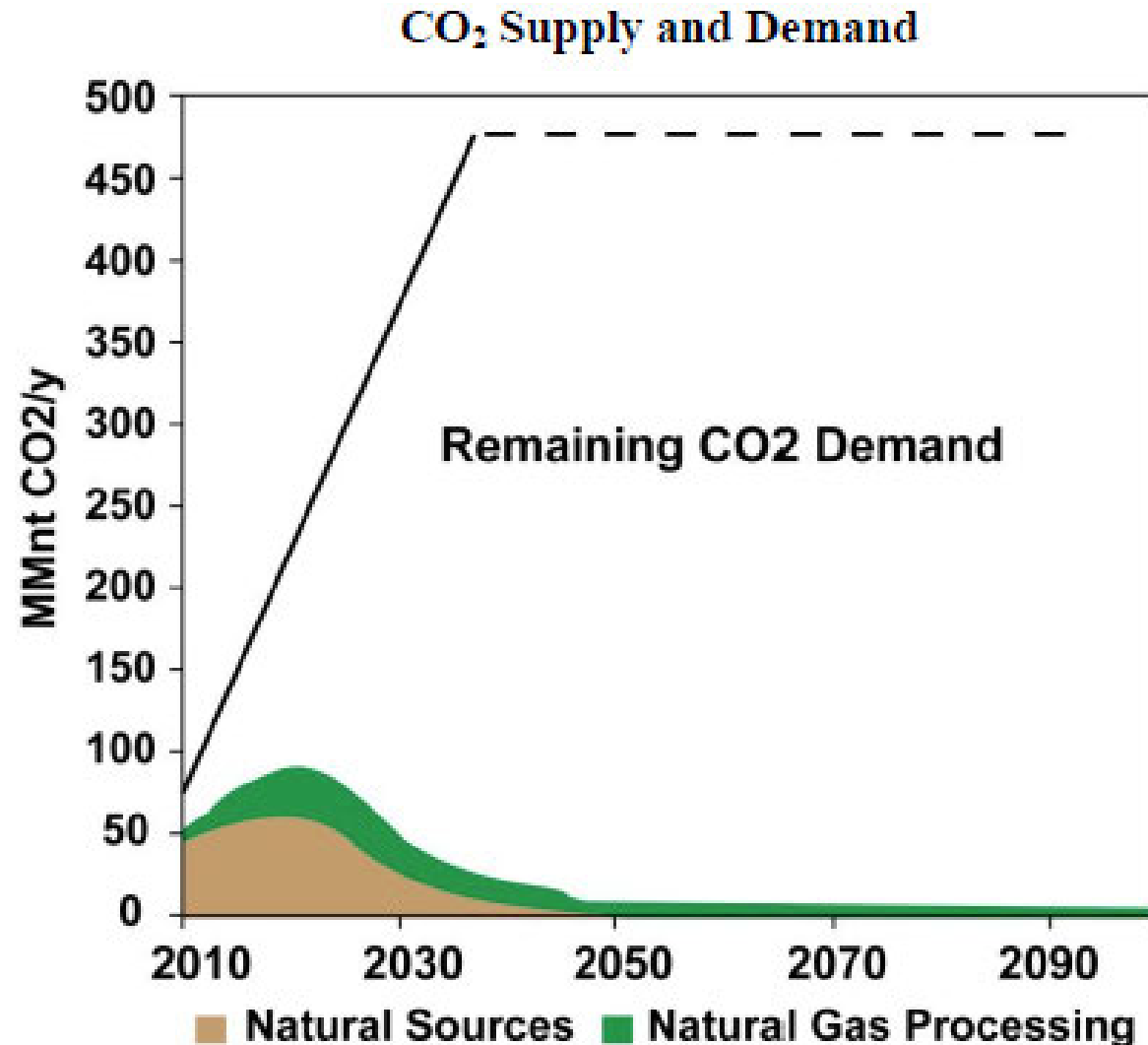


Advanced Resources
International, Inc.

Annual Storage of Industrial CO₂
Using CO₂-EOR



Today's CO₂ Supplies Do Not Meet Demand From EOR



“The only way to increase oil production from EOR is to boost supplies of CO₂ EOR from man-made sources in a manner suitably calibrated to the full potential of EOR,”
NEORI, 2012

source: Hill, Hovorka, Melzer 2009

CO₂-EOR Needs the CO₂ from Coal Power Plants

Demand for CO₂: Number of 1GW Size Coal-Fired Power Plants

(Advanced Resources International, 2012)

Reservoir Setting	Number of 1GW Size Coal-Fired Power Plants***	
	Technical	Economic
L-48 Onshore	170	90
L-48 Offshore/Alaska	31	14
Near-Miscible CO ₂ -EOR	5	1
ROZ**	34	28
Sub-Total	240	133
Additional From ROZ "Fairways"	86	43

**"CO₂ EOR ...can accommodate a major portion of the CO₂ captured from coal fired power plants for the next 30-40 years,"
Kuuskraa, 2012**

*At \$85 per barrel oil price and \$40 per metric ton CO₂ market price with ROR of 20% (before tax)

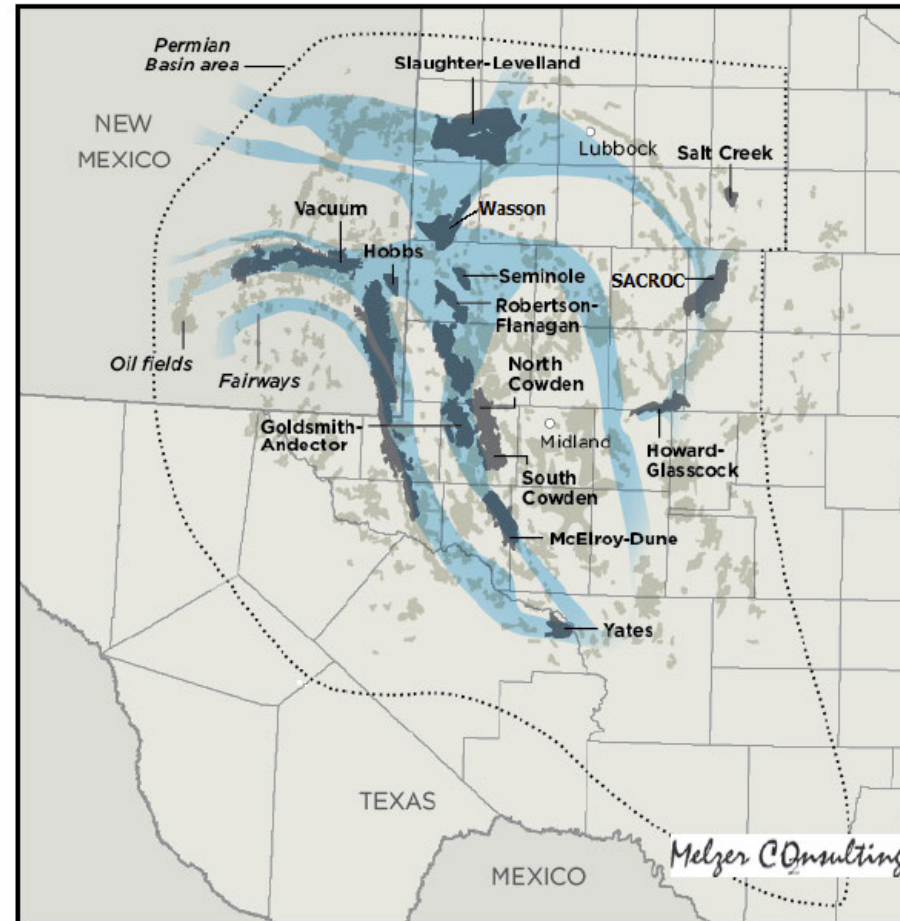
**ROZ resources below existing oilfields in three basins; economics of ROZ resources are preliminary

***Assuming 7 MMmt/yr of CO₂ emissions, 90% capture and 30 years of operation per 1GW of generating capacity; the U.S. currently has approximately 309 GW of coal-fired power plant capacity

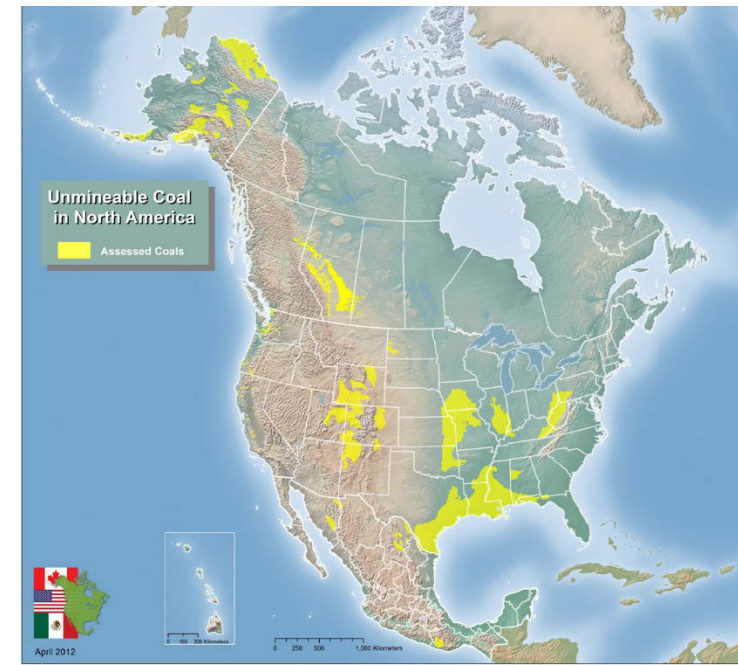
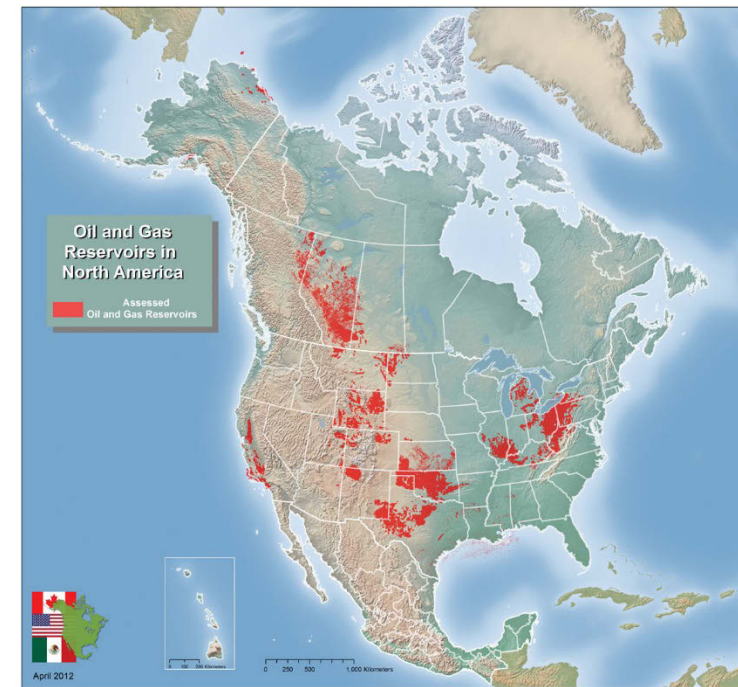
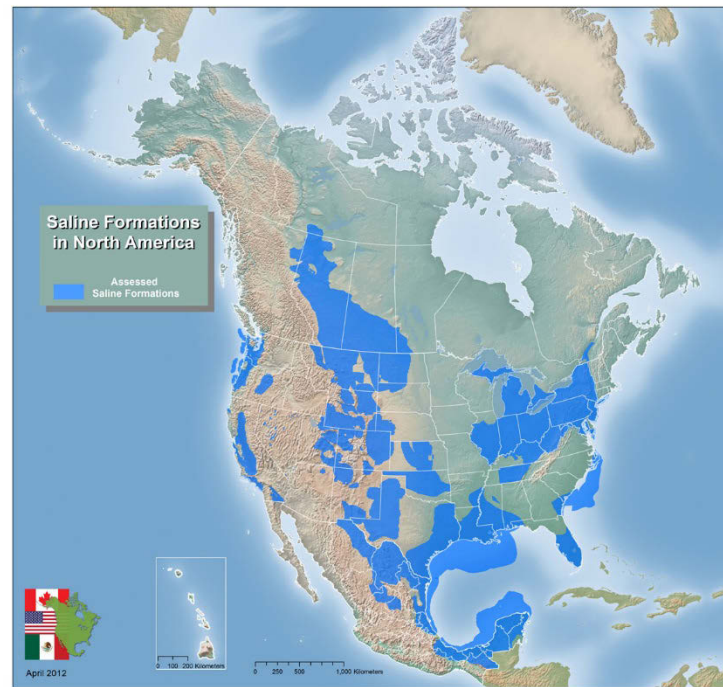
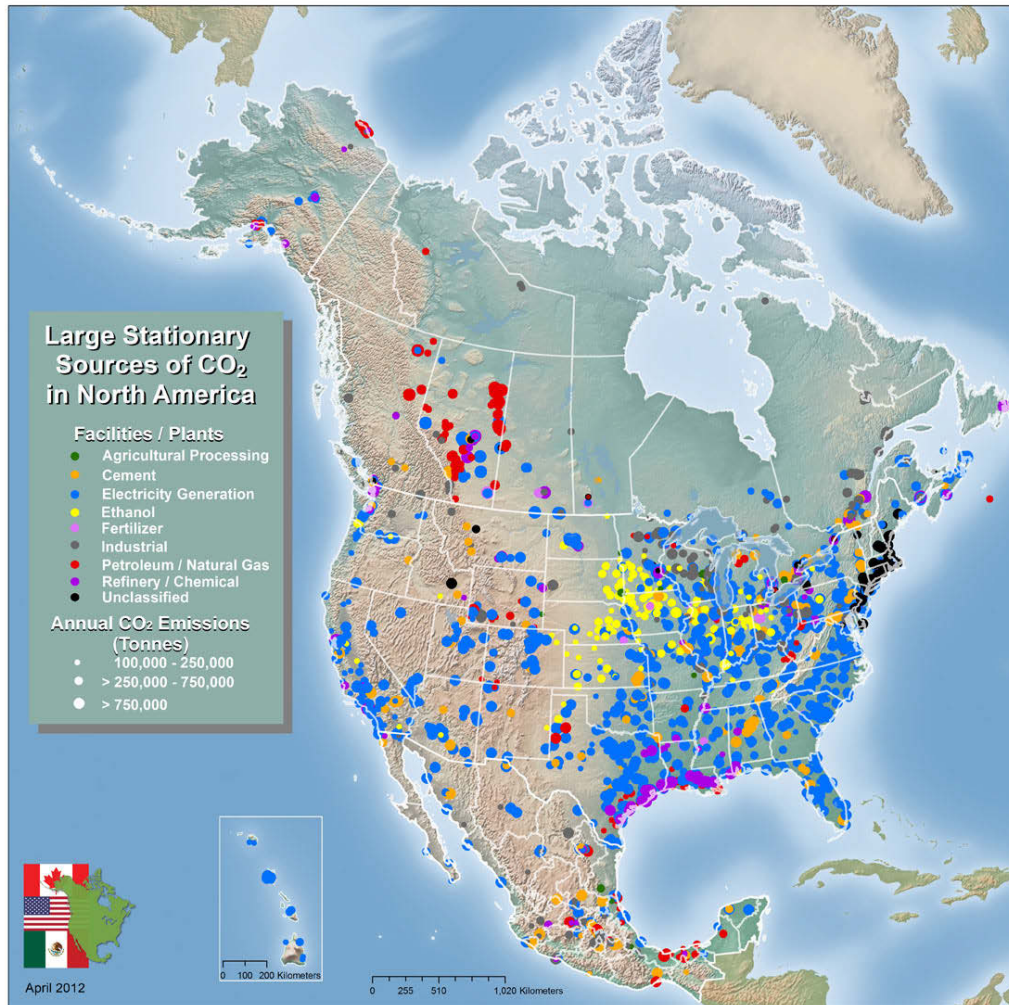
Conventional Oil Fields Are Just the Beginning

- Great potential for CO₂ injection beyond traditional EOR.
- Residual Oil Zones
- Unmineable Coal Beds
- Shale
- Enhanced Gas Recovery

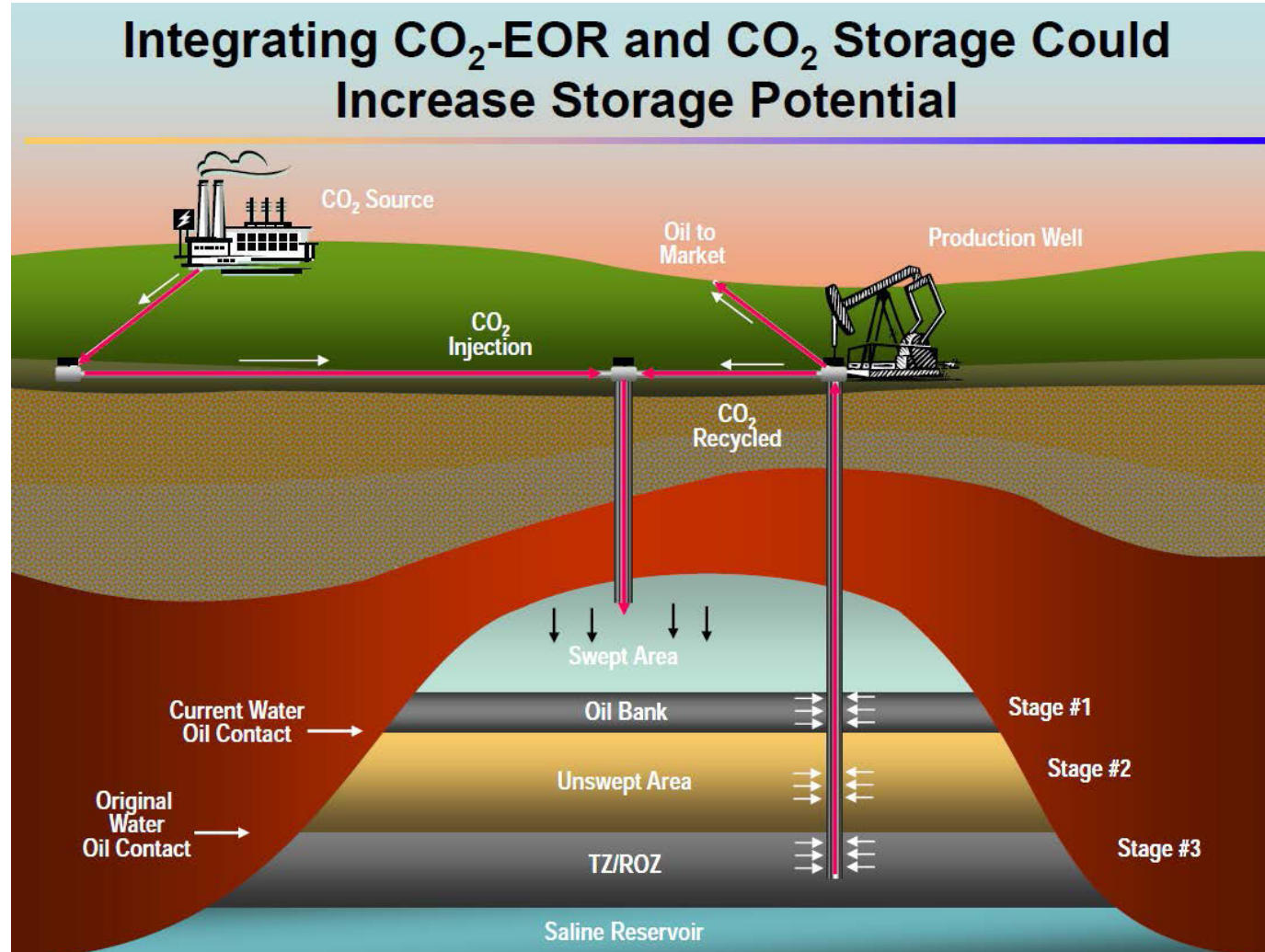
Residual Oil Zone “Fairways”



Sources and Sinks of CO₂ are Both Extensive



CO₂-EOR Combined With Saline Aquifers For Maximum Storage Potential

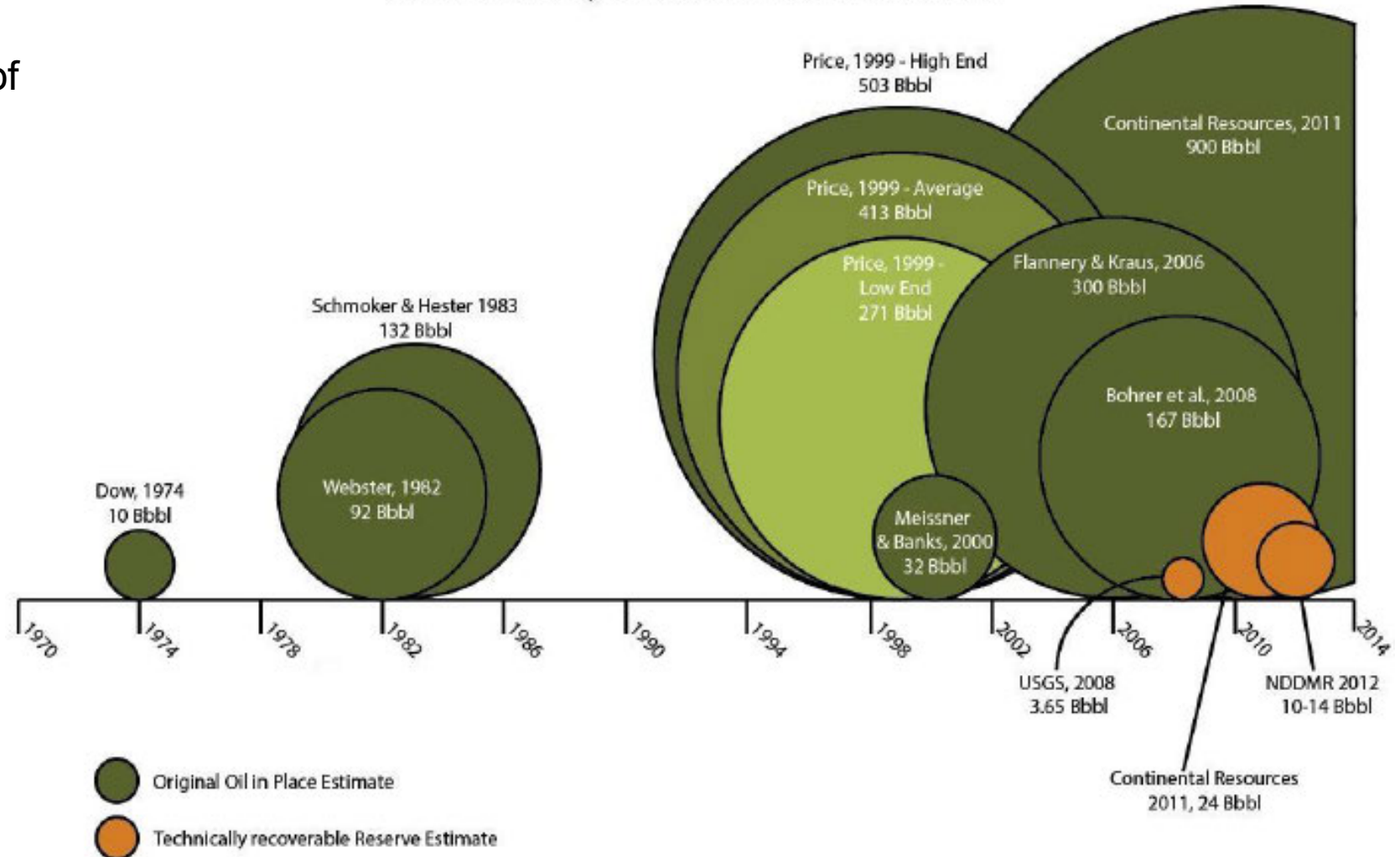


Bakken Shale Offers Substantial Promise

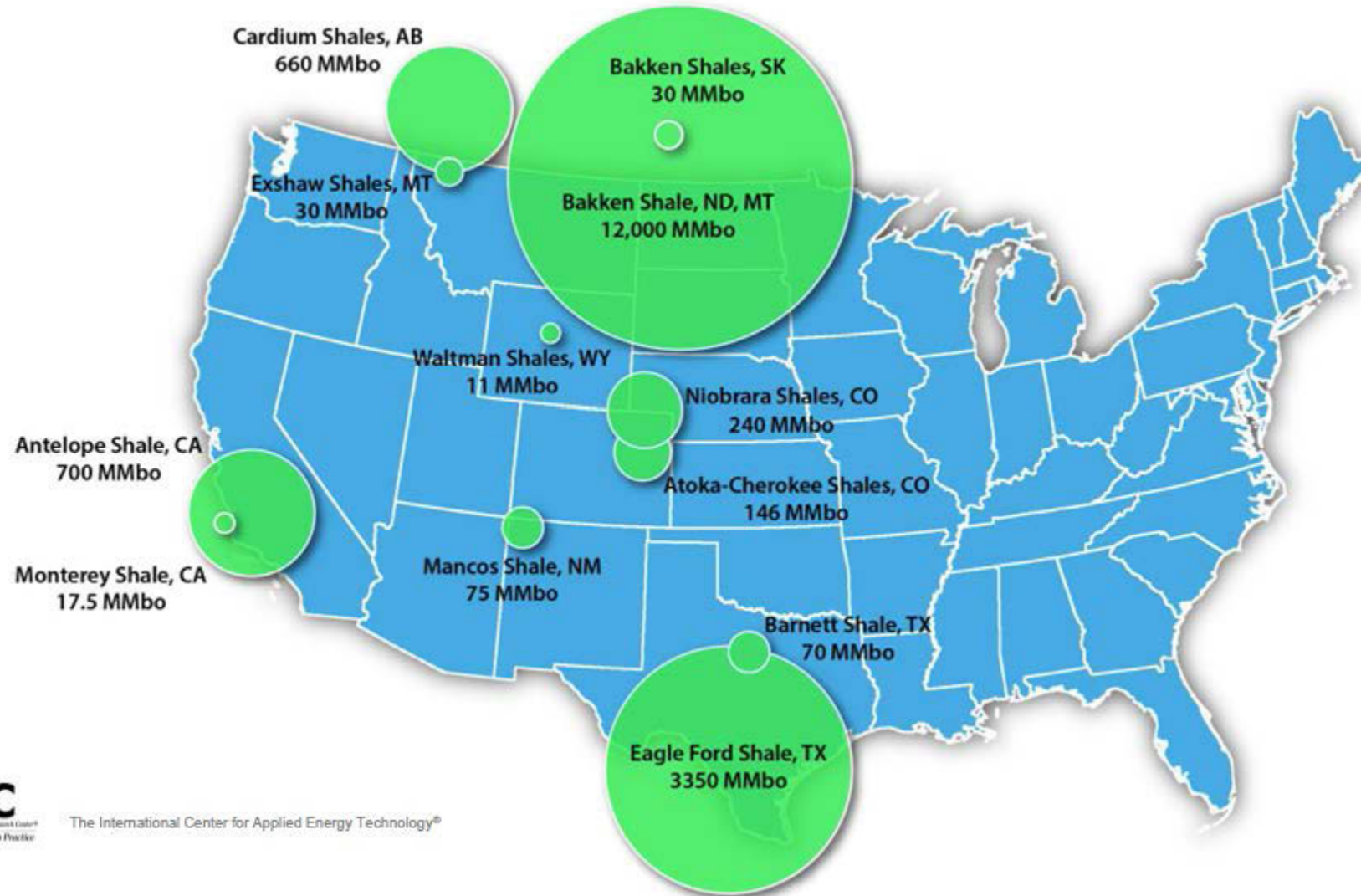
CO₂-EOR is an active area of research in the Bakken.

- Currently, only a 3%–10% recovery factor.
- Small improvements in recovery could yield over a billion barrels of oil.

Bakken Petroleum System Total Oil in Place Reserve Estimates



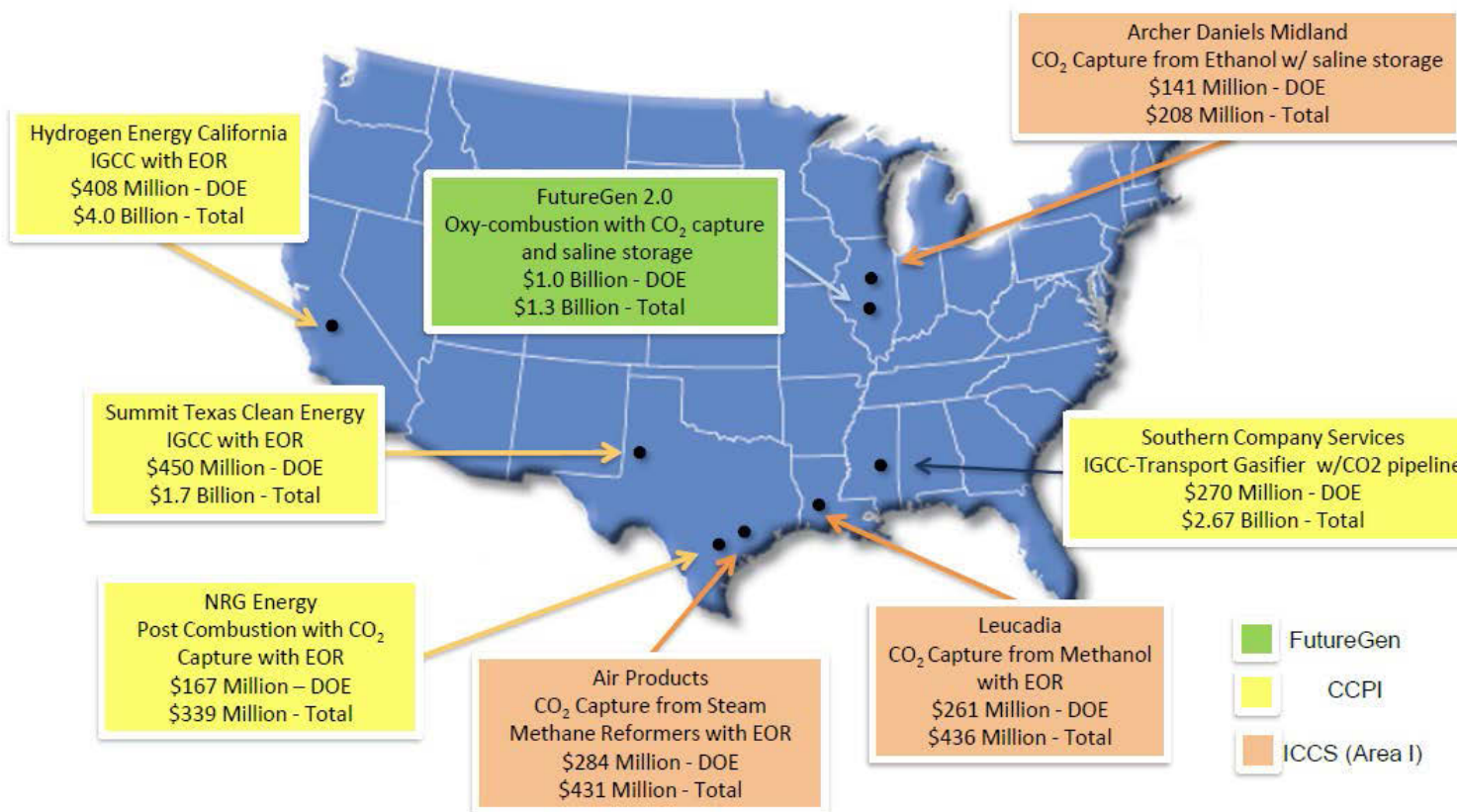
CO₂-EOR in Shale Could be Used in Many Areas



DOE has Invested Heavily in CCUS

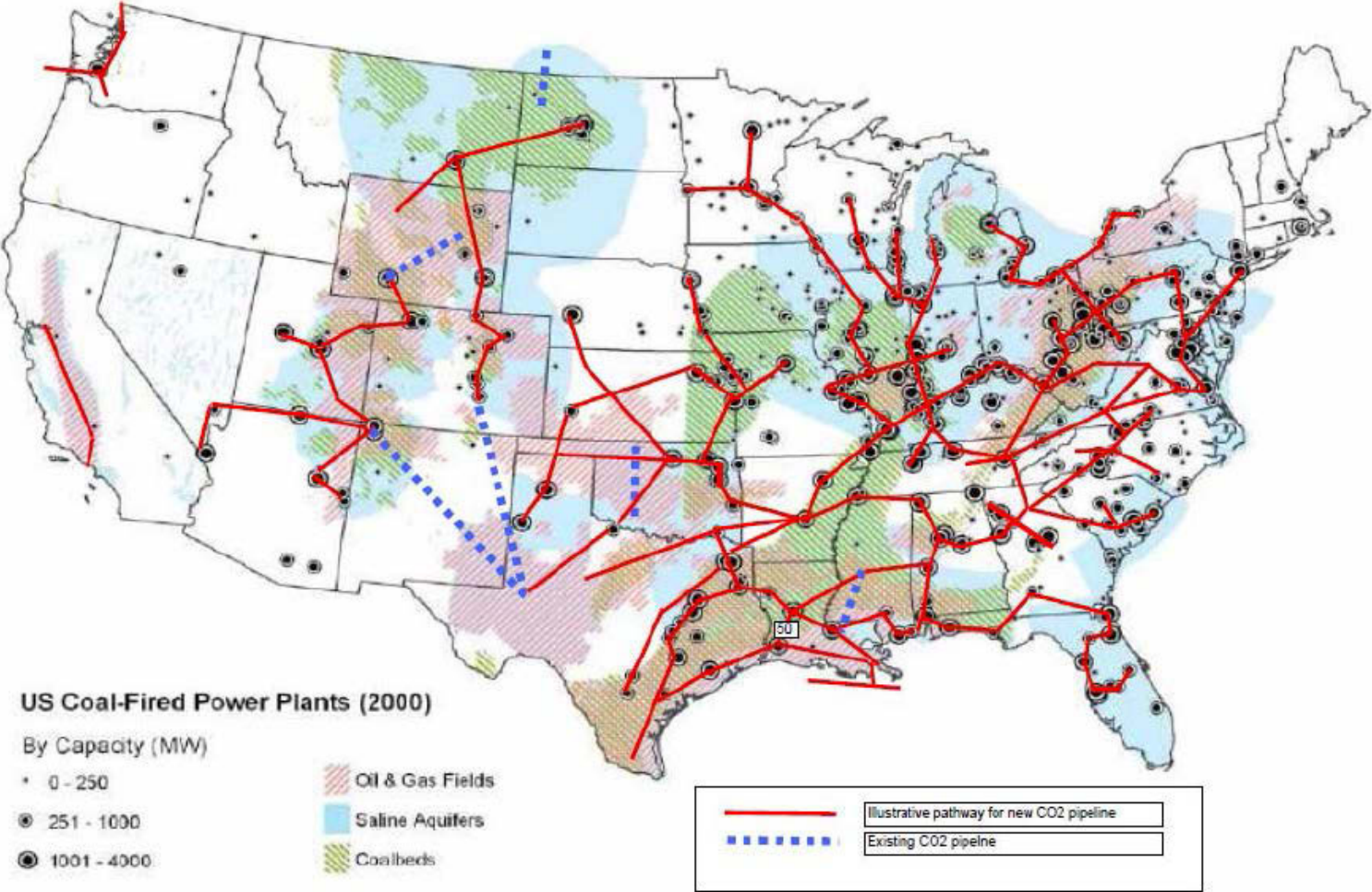
DOE CCUS Demonstration Projects

Focus – Large-scale commercial demonstration of CCUS integrated with coal power generation and industrial sources.



CO₂ Pipeline Expansion Will Be Required

Map of Possible CO₂ Pipeline Corridors for High CCS Case with Greater Use of EOR

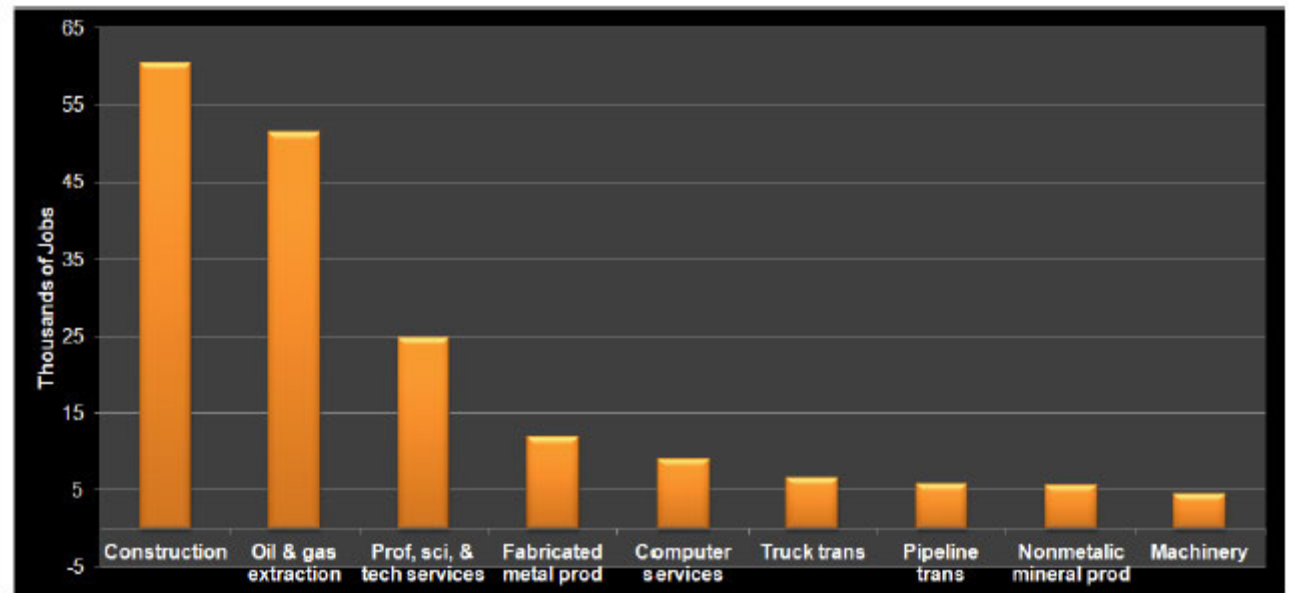


CO₂-EOR Offers Great Economic Potential

Aspirational case study by National Coal Council:

- By 2030, CO₂-EOR industry would generate nearly \$200 billion in annual sales.
- \$60 billion in federal and state and local government tax revenues.
- Revitalize large number of industry sectors and create many professional and technical jobs.

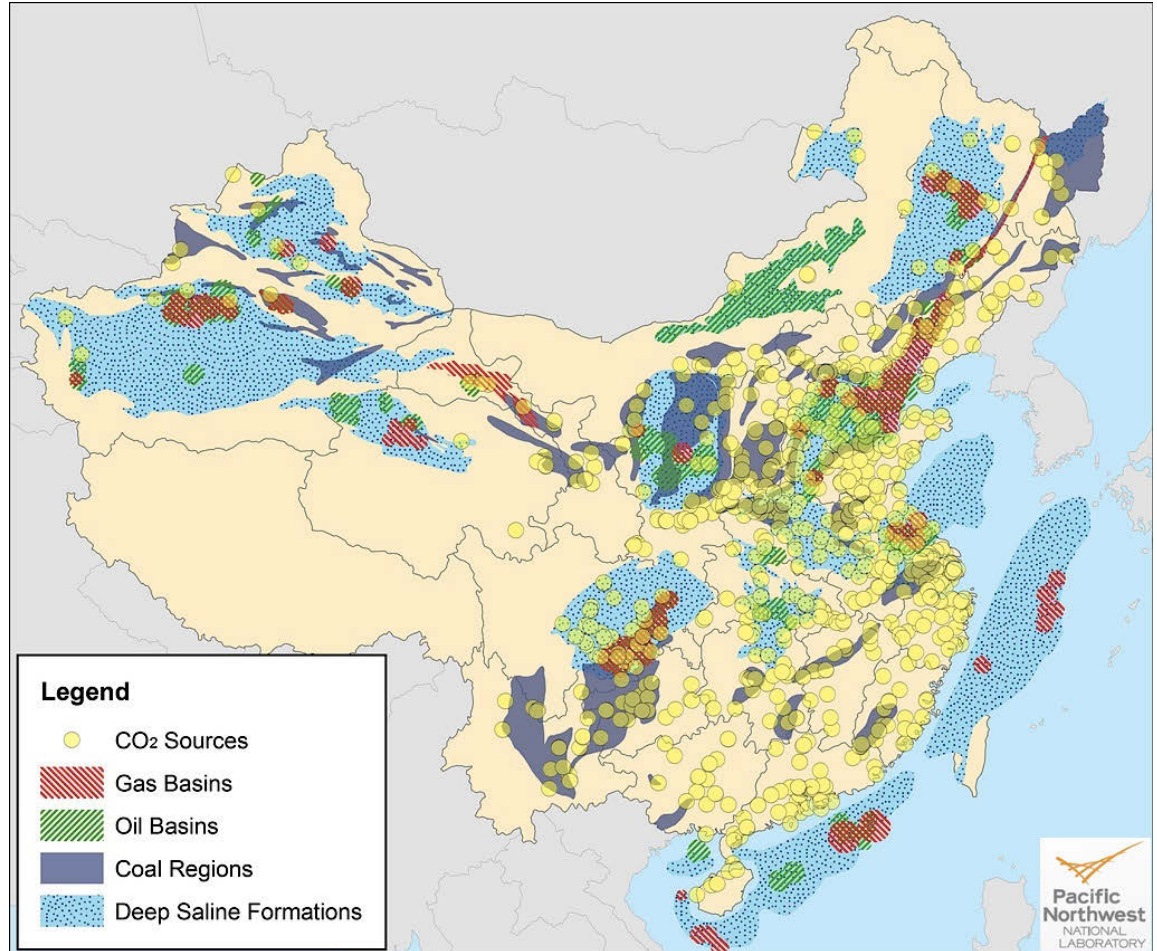
Jobs Created in 2030 by CO₂ EOR
(Selected Industries)



Source: Management Information Services, Inc., 2012.

USA was the Inventor, but China is Now the Leader

- **China is driving innovation in CCUS.**
- China is rapidly building out its coal fleet.
 - One new coal power plant per week.
 - One new coal gasification plant per month.
- China has low cost manufacturing and fast construction speed.
- Western firms heading to China to commercialize new technology.
- USA has greatest potential for EOR, but China is investing in it.
- US-China collaboration benefits the entire world.



EPA is Enacting New Carbon Pollution Standards

- **Clean Air Act**
- On Sept 20, 2013 EPA proposed standards for power plants built in the future under **Section 111 (b)**. - *New Source Performance Standards*
- On June 2, 2014 EPA proposed a plan to cut carbon pollution from existing power plants under **Section 111 (d)**. - *50 Plans For 50 States*
- **Both proposals have been highly controversial.**



CLIMATE CHANGE
AND PRESIDENT OBAMA'S ACTION PLAN



EPA Endorses CCS and CO₂-EOR for New Coal Power Plants



The EPA's [Technical Support Document](#) for the New Source Performance Standards state:

- *Partial carbon capture and storage technology (CCS) is the best system of emission reduction adequately demonstrated (BSER).*
- *CO₂-EOR has been successfully used at many production fields throughout the U.S. to increase oil recovery.*
- *The use of EOR lowers costs for production of domestic oil, which promotes the important goal of energy independence.*
- *The EPA wishes to encourage rather than discourage EOR using captured CO₂ since the practice makes CCS itself more economic.*

Industry Does Not Agree With EPA that CCS is BSER

The National Mining Association submitted comments that represent industry views:

- ***CCS has not been demonstrated at appropriate scale for power plant application and in its current state of development it remains cost prohibitive.***
- ***The costs of CCS are exorbitant and therefore unreasonable.***

New Source Performance Standards will face legal challenge.

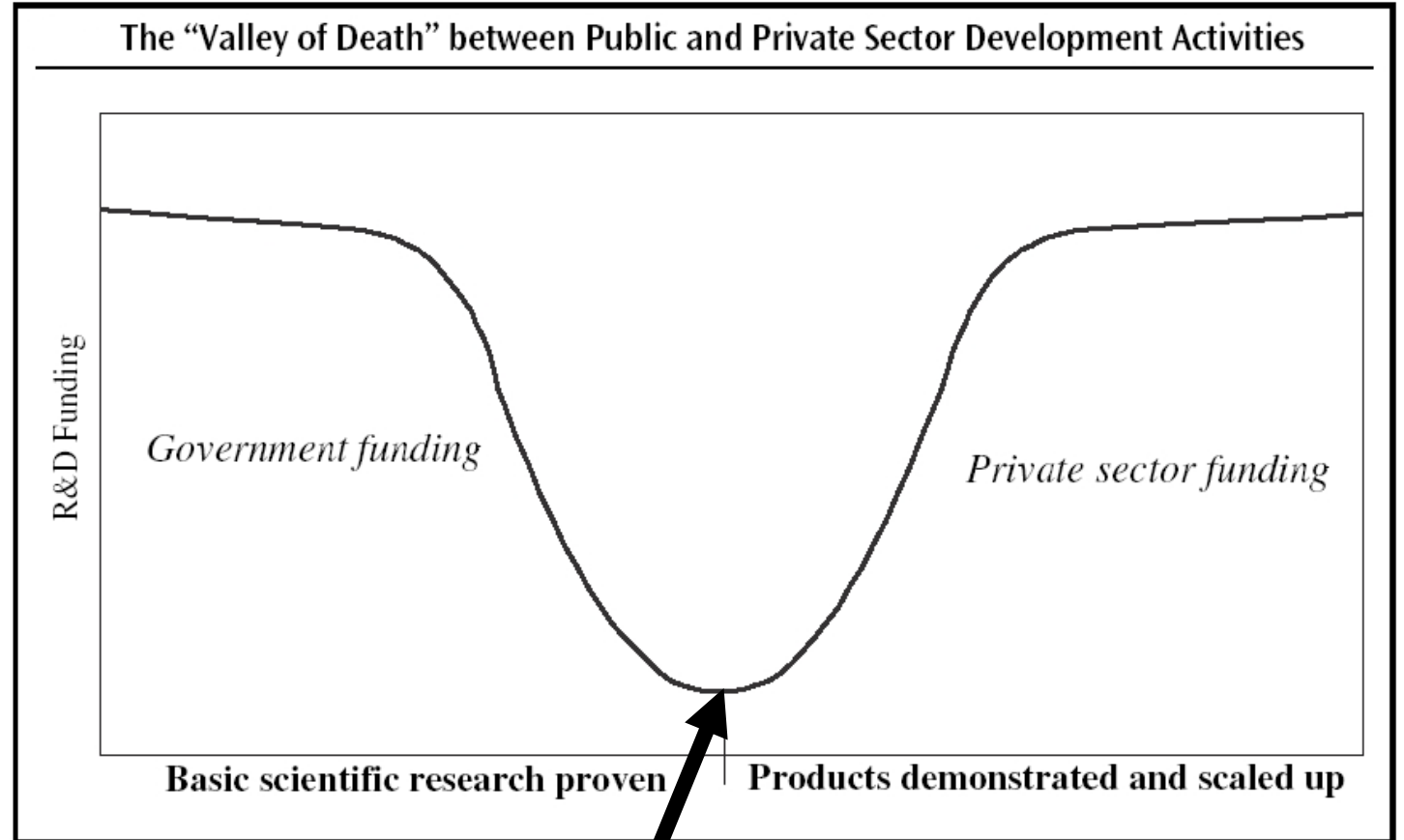


All the Plants Cited by EPA Using CCS Have Needed Public Funding or Have Not Been Built

- **Energy Policy Act of 2005 *prohibits* EPA from basing performance standards on power plants that were funded by DOE's Clean Coal Power Initiative.**
- Kemper, MS – IGCC w/ partial CCS – Major cost overruns and delays and DOE funded.
- Boundary Dam (Canada) – Funded by Canadian Gov't, not yet operational.
- Dakota Gasification – Not a power plant but a coal to synthetic natural gas plant and received significant DOE funding.
- Hydrogen Energy California, HECA – Not begun construction, DOE funded.
- Summit Power, TCEP– Not begun construction, DOE funded.
- **This is legally problematic for EPA's assertion that CCS is “adequately demonstrated” and will be decided in court.**

Fears that Regulations Will Stall CCS Build Out

- EPA states that they expect few, if any, new coal fired power plants to be built.
- EPA expects most new power plants to be NGCC (natural gas combined cycle) with no CCS.



CCS is here. The technology works but is still scaling up commercially.

Price Gap Between Cost of Carbon Capture and Price EOR Industry Will Pay for CO₂.

CO₂ Cost

CO₂ Price



Summary – Industrial Sources of CO₂

Source	Flue Gas % CO ₂	CO ₂ MMSCF/D	Capture Cost \$/ton
• Ammonia Plant	98+	0-37	~ \$19*
• Hydrogen Plant	95+	24	~ \$19*
• Ethylene Oxide	98+	9	~ \$19*
• Ethanol Plant	98+	5-8	\$28-\$38
• Coal Power Plant	12-13	222	\$68
• Natural Gas Turbine	4-5	72	\$83
• Cement Plant	14-33	56	\$45-\$48
• Steel Mill	15-20	184	\$53-\$65

* Cost of dehydration and compression

Rule of thumb is 2-3 % of the crude oil price
 $\$90/\text{bbl} * 2.0\% = 2.25 \text{ \$/mcf} = \mathbf{34 \text{ \$/mt CO}_2}$

~ \$30 per ton difference between cost of carbon capture on coal power plant and sale price for CO₂.

Smart Policies Are Needed To Promote CO₂-EOR

- Current Proposals and Bills:
- NEORI - National Enhanced Oil Recovery Initiative
 - Coalition has proposed a series of federal and state policies to encourage CO₂-EOR.
 - Highlight is federal tax credit for CO₂ capture and transport.
- Senator Rockefeller (D-WV) has 2 bills before Congress.
- Senator Heitkamp (D-ND) ACCTION bill introduced.



National Enhanced Oil Recovery Initiative



**GREAT PLAINS
INSTITUTE**

Better Energy.
Better World.

A coalition of NGO's, industry and elected officials
www.neori.org

- Proposes Federal Tax Credit for companies that capture and transport CO₂.
 - Program would pay for itself within 10 years through revenues earned from oil production.
 - Tax credit provided to owners of CO₂ capture equipment.
 - Applicable to a variety of industries, not just coal.
 - Limited to covering the additional costs for CO₂ capture, compression and transport.

- Recommends modification of existing Section 45Q tax credit for CO₂ sequestration.
 - Existing credit has technical issues in the statute that has prevented it from being utilized.

Identifies detailed series of state level policies, both existing and proposed.

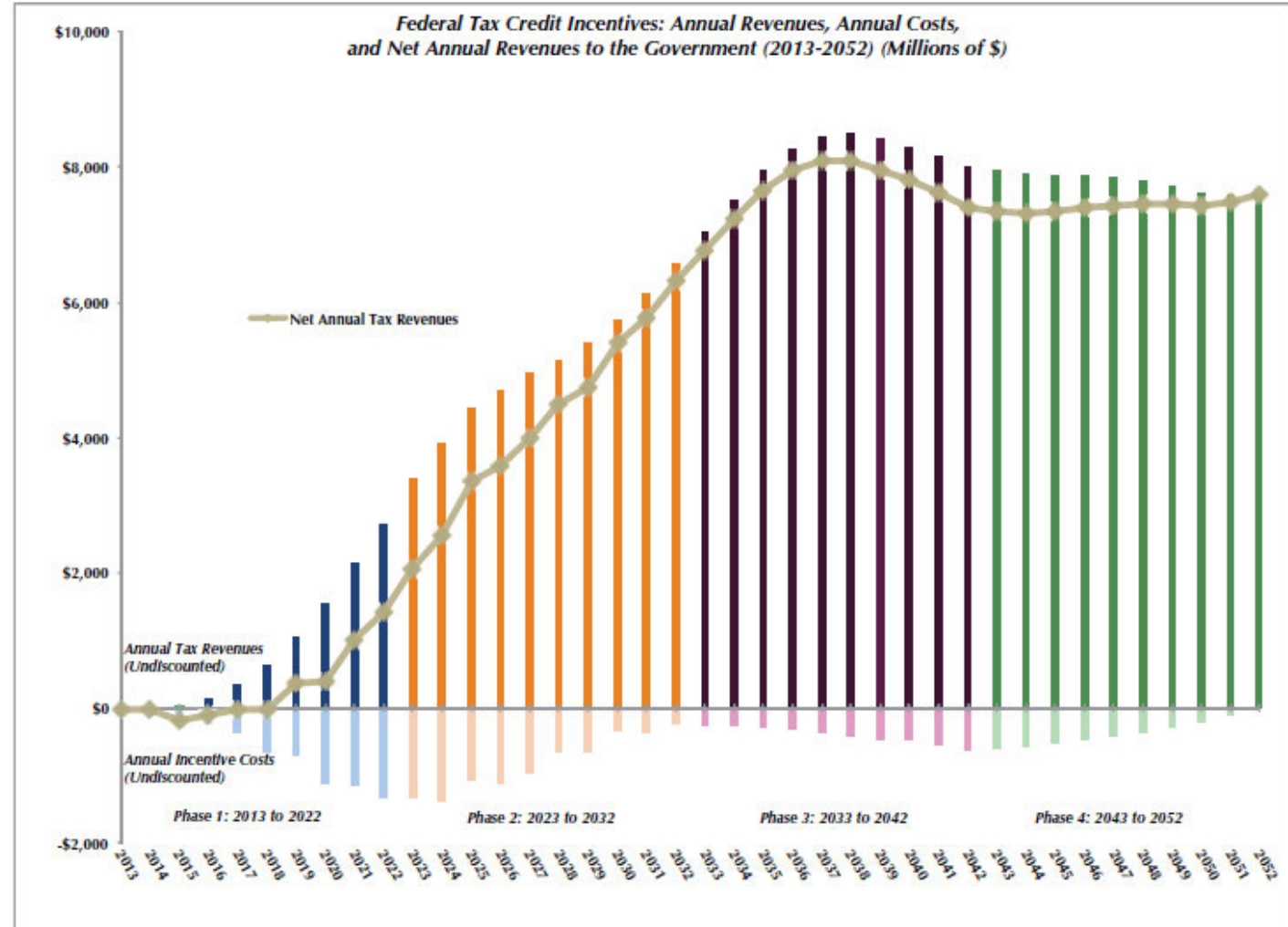


National Enhanced Oil Recovery Initiative

Proposal aligns goals for:

- CO₂ Sequestration
- Domestic Oil Production
- Federal Tax Revenues

Federal CO₂ Production Tax Credit Program Revenues and Costs: Core Scenario



Sen. Rockefeller

Expanding Carbon Capture through Enhanced Oil Recovery Act of 2014 (S. 2288)

- Closely follows NEORI proposals.
- Expands 45Q tax credit.
 - Tax credits awarded via competitive bidding.
 - Bids reflect difference between cost to capture and transport CO₂ and revenue earned from sale for CO₂-EOR.
 - Separate tranches for electric power, low cost industrial and high cost industrial.
- Reforms 45Q tax credit.
 - Certification process allows projects to reserve credits which helps projects obtain private sector investment.
 - Schedules periodic reviews of 45Q program and provides authority to Sec. of Treasury to ensure credits are revenue positive for federal government.
 - Annual tax credit adjustment based on changes in price of oil.
 - Provides ability to transfer credits to entity disposing of the CO₂.

Sen. Rockefeller

Carbon Capture and Sequestration Deployment Act of 2014 (S.2287)

- Carbon Capture & Sequestration Innovation Program
 - Authorize \$1 billion over 15 years for a cooperative industry-government R&D program in DOE.
 - Demonstrate novel and innovative technologies.
 - Industry partners would be required to match up to 20% of the government's investment.
 - Require an annual DOE report to assess program and the current state of CCS deployment.
 - Require GAO review of DOE's efforts.
- Modification to the Carbon Dioxide Sequestration Credit (45Q)
 - Amend current law by allowing projects to apply credits for future use.
 - Limit the amount of credits any one project can receive so that multiple projects can receive credits.
 - Allow credit to be transferred.
- Authorize \$20 billion in loan guarantees for new and retrofit CCS projects.
- Create a new investment tax credit to cover up to 30% of the incremental cost of CCS equipment.

Sen. Heitkamp

Advanced Clean Coal Technology Investment in Our Nation Act of 2014 (ACCTION Act of 2014) (S. 2152)

- **Develop large-scale carbon storage programs** to support commercial application of CO₂-EOR.
- **Increase accessibility of funds in existing federal programs**
 - Direct \$2 billion of current DOE Loan Guarantee Program funding to go to coal projects.
 - Enable projects to receive DOE loan guarantees even if they have received other sources assistance.
 - Streamline process for companies to receive federal funds.
- **Revamp existing R&D programs for advanced coal and CCS.**
- **Increase current tax credit for CCS to 30% and include polygeneration facilities.**
- **Create a variable price support for companies that capture CO₂** to provide long-term certainty to the utilities that sell CO₂ for enhanced oil and gas recovery, regardless of the price of oil.
- **Create clean energy coal bonds** to provide tax credits for coal-powered facilities that sequester CO₂ or meet efficiency targets relative to the current coal fleet.
- **Require reports to Congress from the DOE on the economic and technical status of CCS.**

Regulatory Challenges – Is CO₂ Waste or Commodity?

- EPA regulates CO₂ injection wells under Safe Drinking Water Act.
- CO₂-EOR injection wells historically classified **UIC Class II** (Underground Injection Control).
- Operators are knowledgeable and have decades of successful experience under Class II rules.

- **UIC Class VI** is new program for purpose of geological sequestration.
- No wells have been permitted to date under Class VI rules.
- Class VI rules are complex and costly and not compatible with CO₂-EOR operations.
- Class VI requires owner to monitor well for 50 years, not commercially feasible for CO₂-EOR.

Recommendations:

- Regulatory certainty is necessary for the development of a robust CCUS and CO₂-EOR industry.
- Deployments are needed to bring costs down and get beyond *First Of A Kind* economics.
- Long distance CO₂ pipeline infrastructure is needed.
- New coal plants need to be strategically sited close to coal sources and close to CO₂ sinks.

Final Thoughts:

- In a world of growing energy demand we need all sources of energy.
- Hydrocarbons are not going away.
- Carbon sequestration is critical to addressing carbon pollution and climate change.

- **We must rethink how we use coal.**
- Coal to Synthetic Natural Gas and Coal to Liquids offer improved economics for carbon capture.
- Synthetic diesel, gasoline and jet fuel from coal, biomass and garbage are ultra-pure.
- Coal ash has excellent properties in use as cement and it improves the carbon footprint of concrete. It is lose-lose to waste coal ash by leaving it in polluting piles.
- Coal is a critical domestic resource, it is foolish to consider to abandoning it while we continue to fight wars overseas to secure access to hydrocarbons.