

LOWERING ETHANOL CARBON INTENSITY WITH CO2 CAPTURE AND ENHANCED OIL RECOVERY

BIOECONOMY 2017

JULY 12, 2017



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Great Plains Institute Today

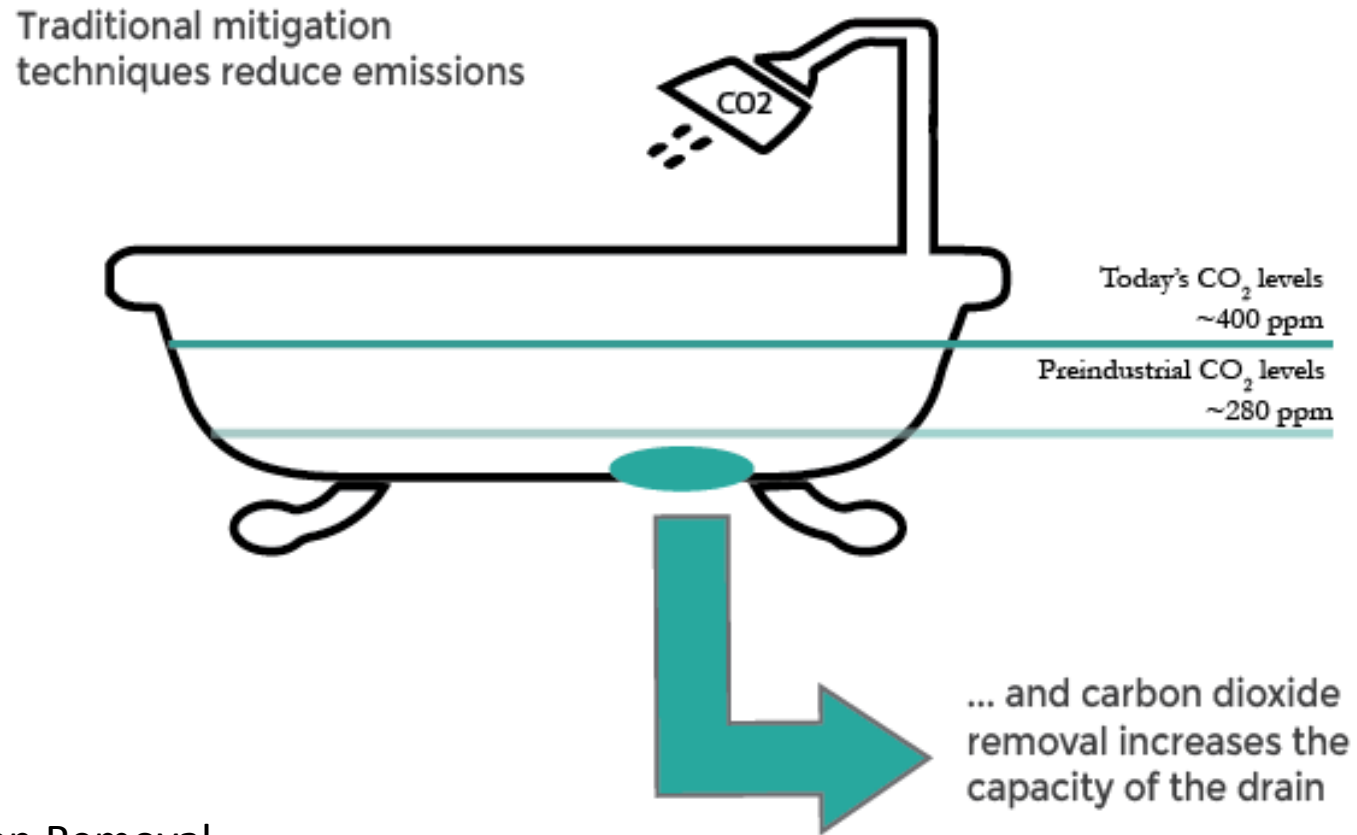
Mission: To transform the way we produce, distribute, and consume energy to be both economically and environmentally sustainable.

20-yr. old non-partisan, non-profit that:

1. Develops better energy policy via consensus.
2. Catalyzes deployment of best energy technologies, practices & programs.
3. Provides reliable analysis & decision tools.



Carbon removal – essential for 1.5 or 2°C scenarios



Source: Center for Carbon Removal

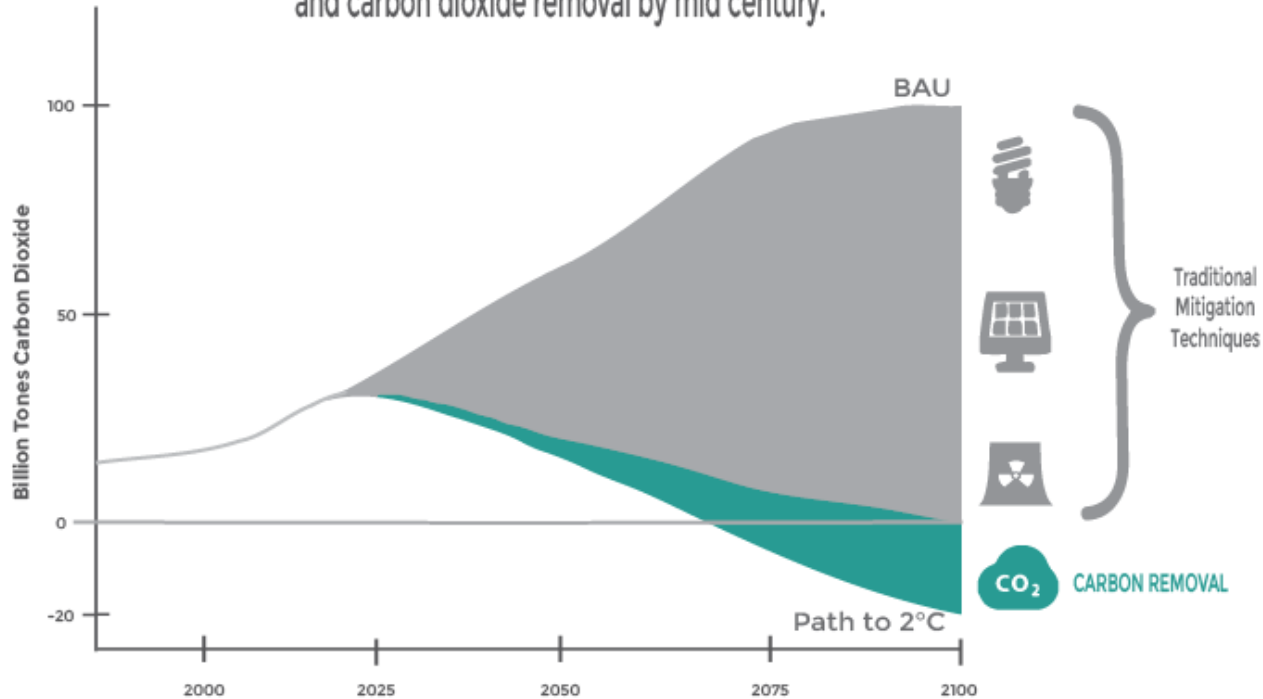


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Biomass + carbon capture

Keeping temperatures below 2°C requires both reducing emissions today and carbon dioxide removal by mid century.



Only carbon dioxide removal can bring emissions “below zero”

Source: Center for Carbon Removal

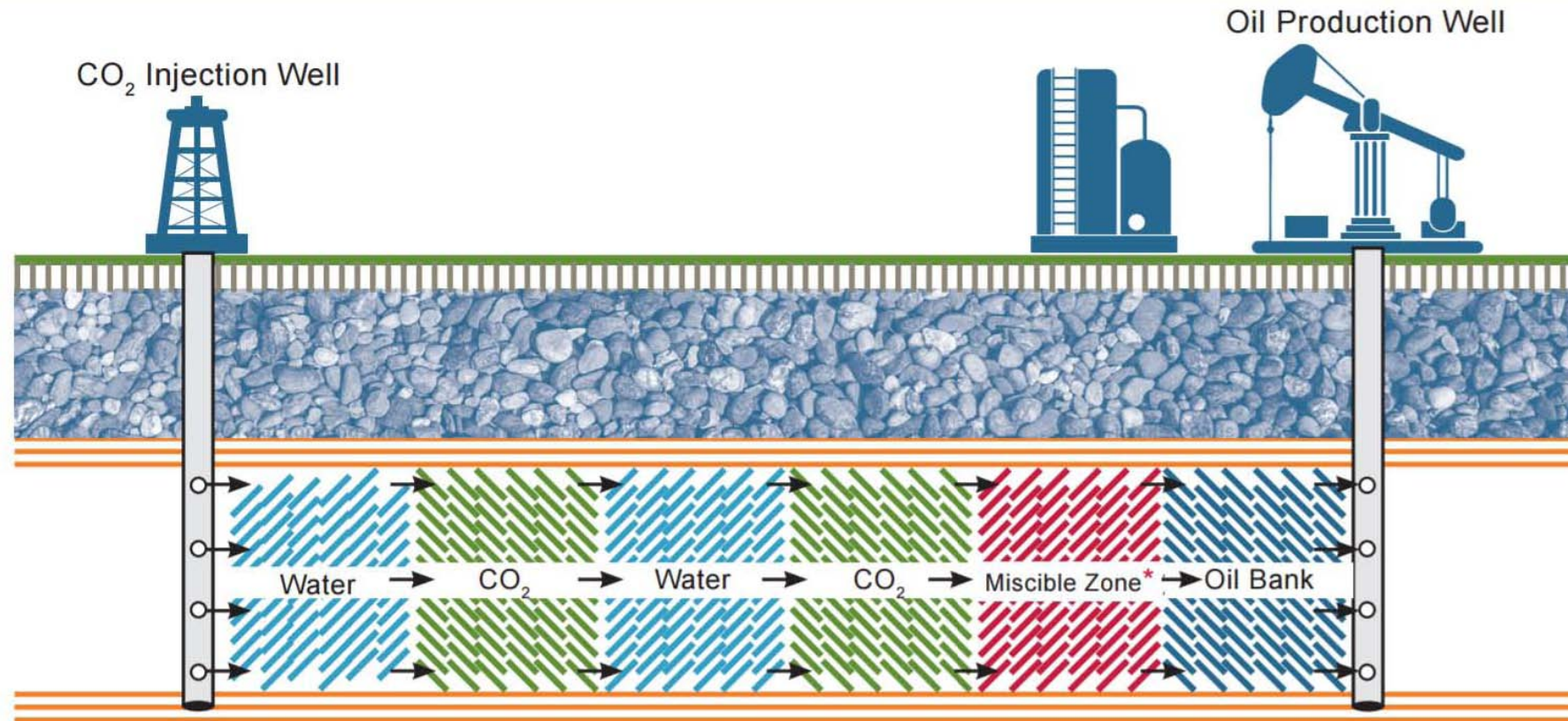
- 101 of 116 430-480ppm scenarios in IPCC AR5 rely on biomass + CCS
- 67% have biomass + CCS exceeding 20% of primary energy 2100
- 2-10 GT CO₂ storage required by 2050



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Figure 4: How Carbon Dioxide and Water Can Be Used to Produce Residual Oil



*Miscible Zone = Injected CO₂ encounters trapped oil → CO₂ and oil mix → Oil expands and moves towards producing well

Source: National Energy Technology Laboratory, "Carbon Dioxide Enhanced Oil Recovery: Untapped Domestic Energy Supply and Long Term Carbon Storage Solution," March 2010.



Fortunately, CO₂-EOR is a Safe, Commercially Proven and Long-Standing CCS Pathway in the U.S.

- Over 40 years experience, beginning at significant scale in West Texas in 1972.
- Over 300,000 barrels of oil per day:
 - 110 million barrels annually, or about 4 percent of U.S. domestic production.
- Over 4,500 miles of CO₂ pipelines
- Over 67 million tons of CO₂ injected and stored each year.
- 13 million tons of CO₂ from man-made sources.
- To date, more than 1.5 billion barrels of oil have been recovered via CO₂-EOR.

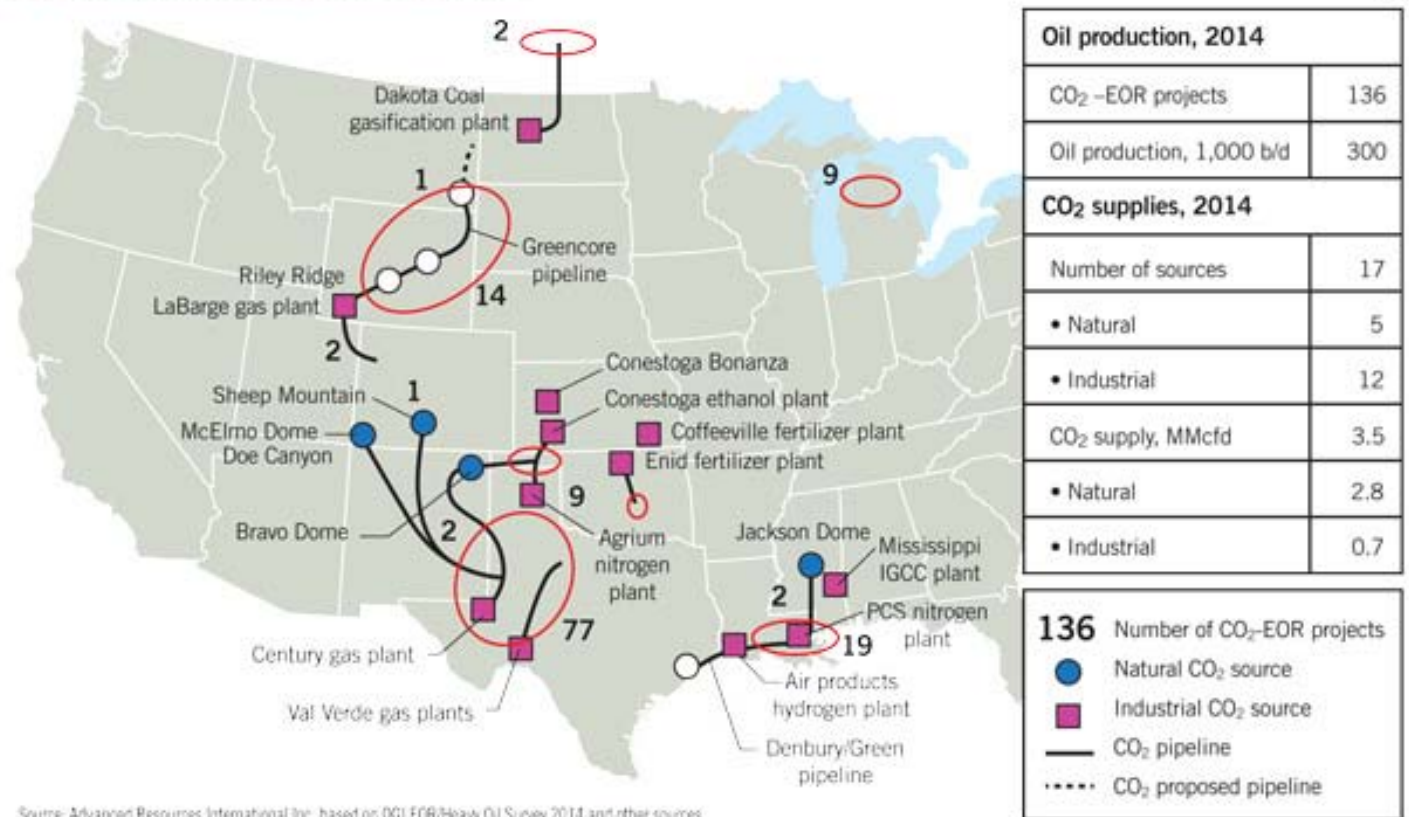
Source: Melzer, 2012



Map of Current CO₂-EOR Activity and Infrastructure: Over 4,500 Miles of CO₂ Pipelines in U.S. Today

CO₂-EOR OPERATIONS, CO₂ SOURCES: 2014

FIG. 1



Source: Advanced Resources International Inc. based on OGI EOR/Heavy Oil Survey 2014 and other sources

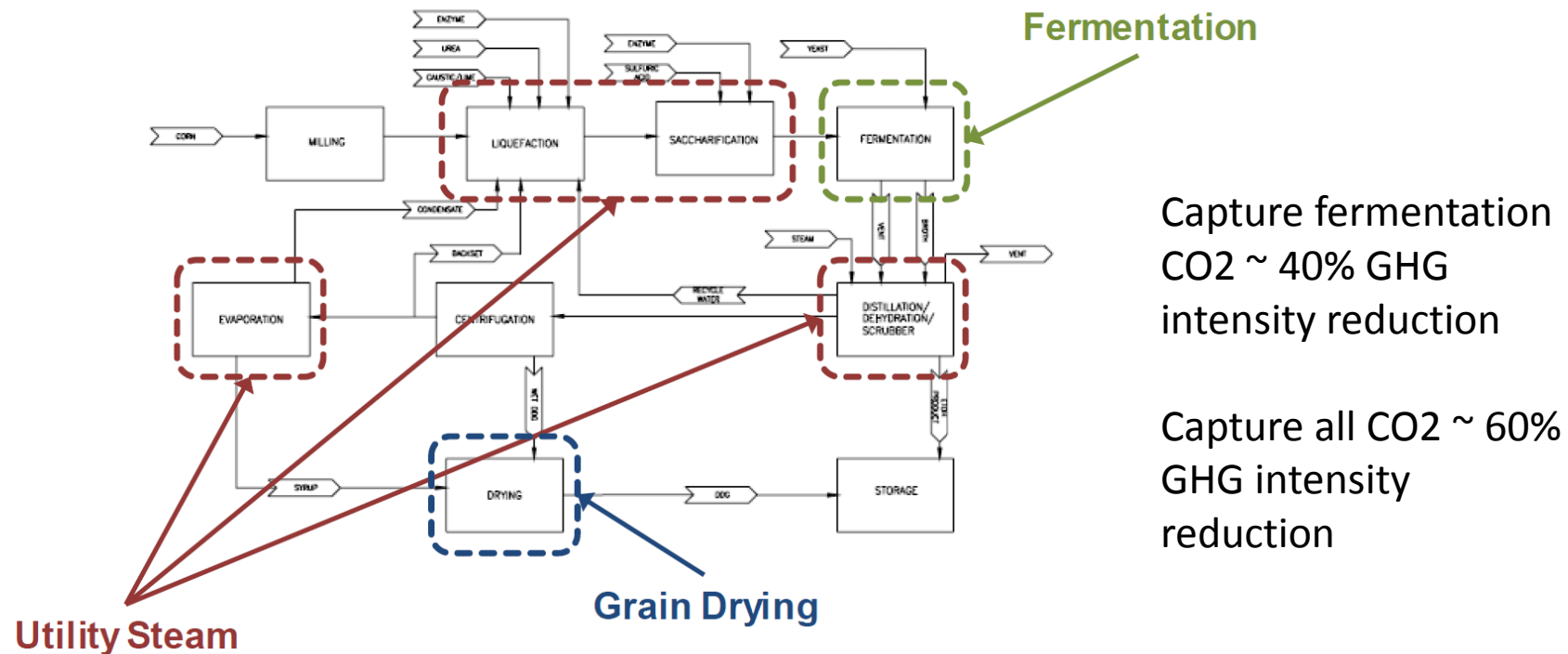
Source: Oil & Gas Journal, 2014, available at: <http://www.ogi.com/content/dam/ogi/print-articles/volume-112/april-07/z140407OGJsku01.jpg>



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Potential for ethanol CO₂ capture



Slide and data courtesy of Sean McCoy, Lawrence Livermore National Laboratory

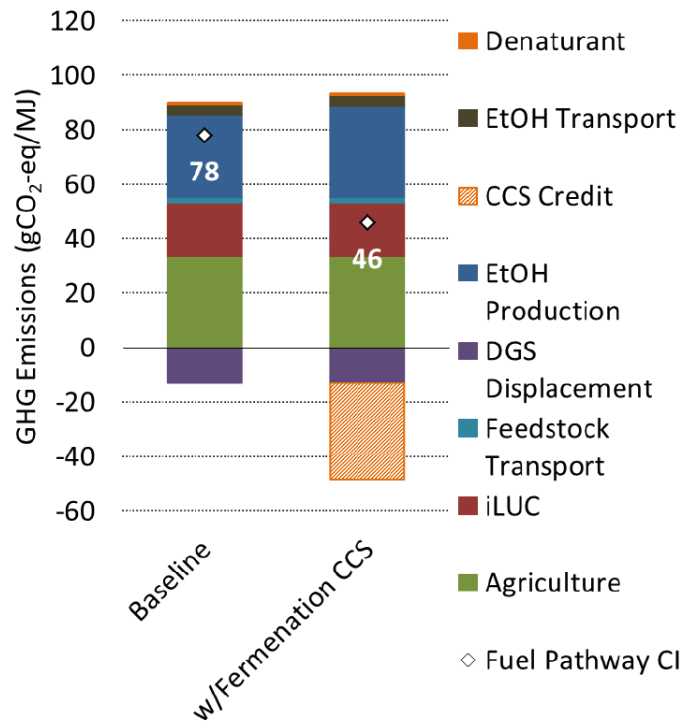


Two examples of ethanol + EOR

- Arkalon ethanol plant: 313,830 mt CO₂ to Booker and Farnsworth oil fields in Texas, operated by Chapparral Energy.
 - 90 mile pipeline
 - Net sequestration ratio: 1.3 (30% more captured CO₂ than burned in the oil)
- Bonanza ethanol plant: up to 156,915 mt CO₂ to the Stewart oil field near Garden City, KS, operated by PetroSantander, Inc.
 - 15 mile pipeline



Case study: breakeven costs for capture of fermentation CO₂



- Project life of **10 years**
- 15% discount rate
- CAPEX and non-energy OPEX per Illinois Basin Decatur Project
- \$40/MWh electricity cost (MISO)
- **\$10/t transport and storage cost**

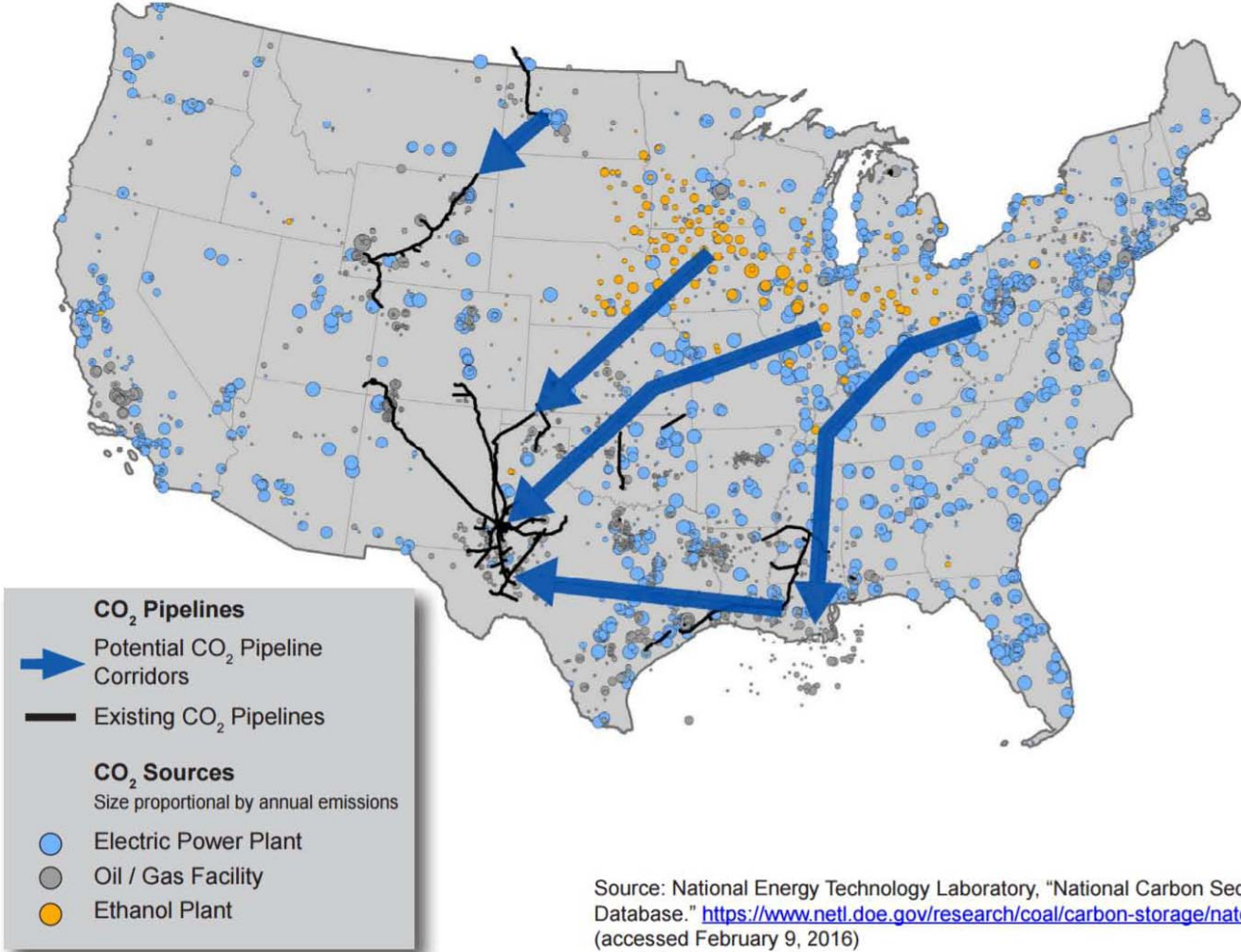
LCFS credit prices range from ~\$70 – 140/ton

Total Capital Cost	\$12,893,000
Fixed and Variable Cost	2,833,000/y
Incremental Cost	\$0.09/gal
Avoidance Cost (LC Basis)	\$35/t

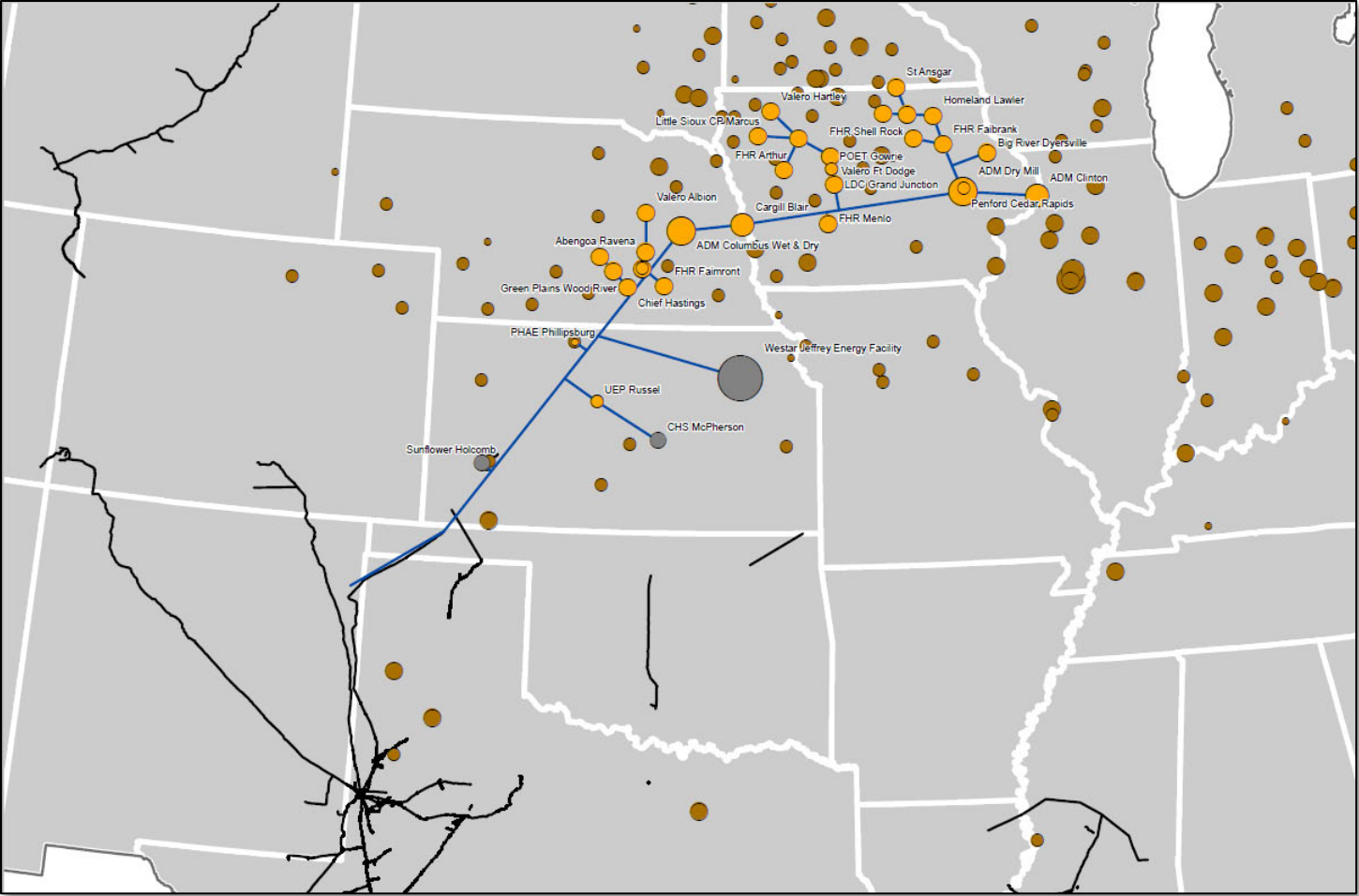
Slide and data courtesy of Sean McCoy, Lawrence Livermore National Laboratory



Connecting CO₂ to EOR Markets



Bringing ethanol CO₂ to the Permian Basin

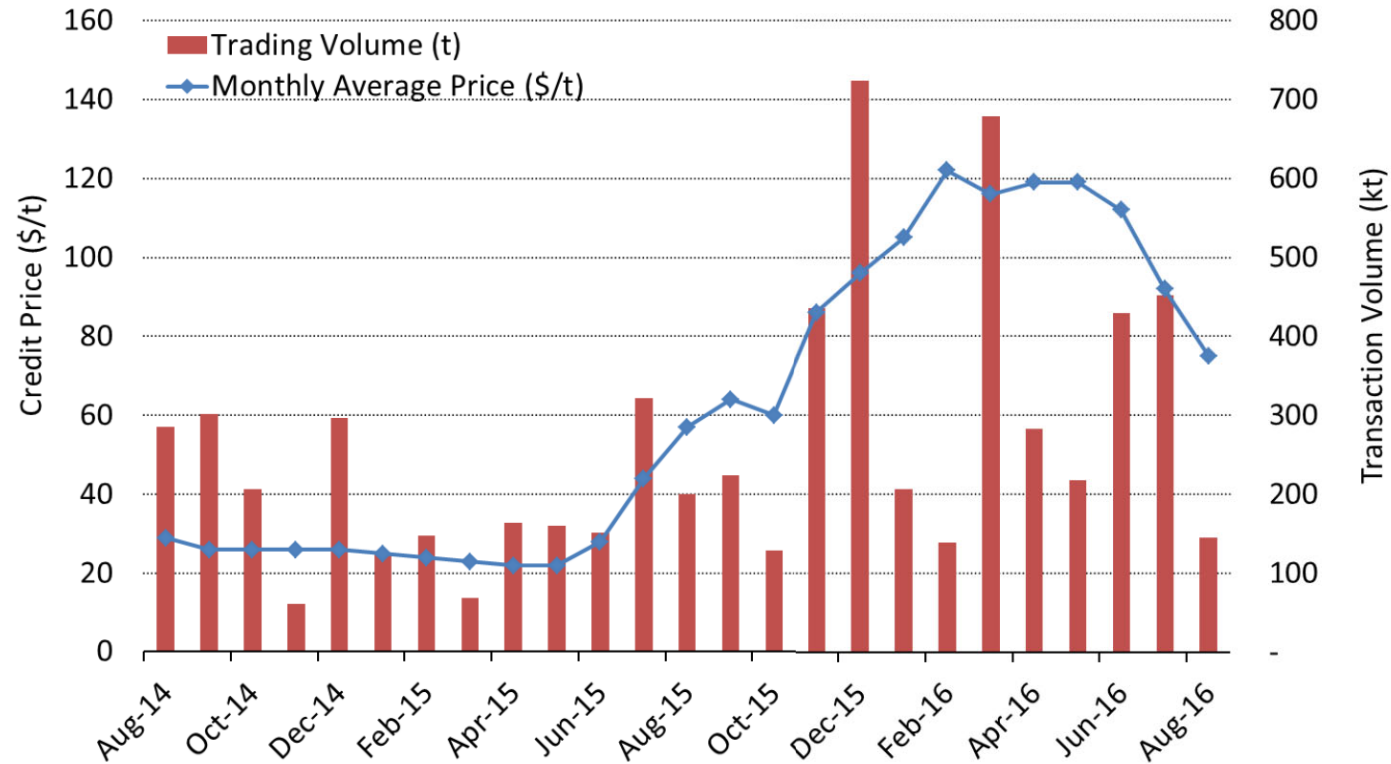


Economic/Policy drivers for ethanol CO₂ capture

- EOR markets
- California/Oregon/British Columbia LCFS
- EU renewable fuel policies
- 45Q tax credit



August 2016 LCFS price was \$75/tCO₂



[ARB \(2016\)](#) trading data

Slide and data courtesy of Sean McCoy, Lawrence Livermore National Laboratory



Will CARB allow CCS?

- CARB developing a “quantification methodology” to determine how to treat CCS/EOR in relation to ethanol plants.
- Currently in process. Expected to be released in 2017.
- Ethanol plant doing CCS (EOR or saline) would need an approved LCFS pathway, could potentially apply in early 2018.



Top Coalition Priority: Extend, Reform and Expand Existing Federal Section 45Q Tax Credit for CO₂ Storage

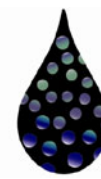


Key reform elements:

- **Increase financial certainty** for carbon capture project investors by eliminating the existing cap on credits (current credit about to run out).
- **Increase the credit value** to close the gap between the cost of carbon capture and revenue from the sale of CO₂ for EOR.
- **Expand industrial sector participation** by lowering tonnage threshold for eligibility of carbon capture projects.
- **Enhance flexibility** in utilization of the tax credit to allow for multiple business models, including participation of tax-exempt electric cooperatives, municipal utilities and many other project developers.



NEORI's Diverse Membership Reflects the Many Benefits and Broad-Based Support for CO₂-EOR



National Enhanced
Oil Recovery Initiative

Coal

- Arch Coal
- Cloud Peak
- Peabody Energy

Electric Power

- Great River Energy
- NRG Energy
- Summit Power Group
- Tenaska Energy

Oil and Gas

- Core Energy
- Occidental Petroleum Corporation

Ethanol

- Archer Daniels Midland
- Conestoga Energy Partners, LLC
- White Energy

Industrial Suppliers of CO₂/Technology

- Air Liquide
- Air Products
- Alstom
- GE Oil & Gas
- Jupiter Oxygen
- Linde
- Praxair

Project Developers

- EBR Development, LLC
- Lake Charles Methanol

Environmental and Energy Policy NGOs

- Center for Carbon Removal
- Clean Air Task Force
- Energy Innovation & Reform Project
- Global Carbon Capture & Storage Institute
- Jackson Hole Center for Global Affairs
- Natural Resources Defense Council
- Wyoming Outdoor Council

Labor

- AFL-CIO
- International Brotherhood of Boilermakers
- International Brotherhood of Electrical Workers
- SMART Transportation Division
- United Mine Workers of America
- Utility Workers Union of America

Observers

- Chaparral Energy
- Enhanced Oil Recovery Institute
- Interstate Oil and Gas Compact Commission
- LI-COR Biosciences
- Mitsubishi Heavy Industries of America, Inc.
- Tellus Operating Group

Bipartisan Support for 45Q Unparalleled for Energy & Climate Legislation of Its Kind



- In 2016, **one-fifth of Senate supported** Carbon Capture, Utilization and Storage Act (S. 3179) introduced by Heidi Heitkamp (D-ND), including GOP Senate Majority Leader Mitch McConnell, Energy Committee Chair Lisa Murkowski, and Assistant Minority Leader Dick Durbin:
 - GOP co-sponsors: Capito (WV), Blunt (MO), McConnell (KY), Barrasso (WY), Murkowski (AK), Portman (OH), Kirk (IL), and Graham (SC)
 - Democratic co-sponsors: Whitehouse (RI), Tester (MT), Schatz (HI), Booker (NJ), Kaine (VA), Casey (PA), Klobuchar (MN), Durbin (IL), Franken (MN), Brown (OH), and Warner (VA)
- Over **10 percent of House supported** Rep. Mike Conaway's (R-TX) H.R. 4622: 50 co-sponsors spanning political spectrum from the Freedom Caucus to Congressional Black Caucus (32 Rs and 17 Ds, from 26 states).



Anticipated Elements of 2017 45Q Legislation

House: Carbon Capture Act

• Specifications

- Keeps existing 45Q threshold in place for current projects
- Credit for EOR storage and saline storage increases to \$35. There is only one credit
- Ramps credit for 10 years
- Reduces 500,000 threshold to 100,000 tons for all facilities– was 150,000
- Includes stronger transferability provision from last year’s Senate bill
- Authorizes programs for projects that commence construction within 7 years
- Credit can be claimed for 15 years once placed in service
- Adds language to allow carbon monoxide capture and direct air capture to get the credit
- Credit authorization language is changed to allow all projects that “have never received 45Q tax credit before” to qualify (NRG, Petra Nova, and Core Energy)

Senate: Carbon Capture, Utilization & Storage Act

• Specifications

- Keeps existing 45Q threshold in place for current projects
- Credit for EOR storage increases to \$35 and \$50 for saline storage
- Ramps credit over 10 years
- Reduces 500,000 threshold to 100,000 for industrial and 25,000 threshold for non-EOR utilization and keeps 500,000 threshold for electric generating units
- Includes stronger transferability provision
- Authorizes programs for projects that commence within 7 years
- Credit can be claimed for 12 years once placed in service
- Provides eligibility for new forms of CO₂ (algae, biomass, alternative fuels, etc.)
- Adds language to allow carbon monoxide and direct air capture to get the credit
- Credit authorization language is changed to allow electric power projects that “have never received 45Q tax credit before” to qualify (NRG/Petra Nova)



Conclusions

- Don't focus only on cellulosic and advanced biofuels – additional decarbonization of conventional biofuels important.
- Carbon removal an essential part of carbon mitigation, biomass a crucial part of most viable mitigation pathways.
- Level of deployment needed by 2100 is intimidating, but progress is possible near-term.
- Biomass + carbon capture can create unique political coalitions bridging red and blue states, multiple constituencies.



THANK YOU!

Brendan Jordan
bjordan@gpisd.net
612-278-7152



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