"CO_2 For EOR in North America-History and Status"

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NACCSA North American Carbon Capture & Storage Association

Astrup Fearnley

FearnOil Inc.

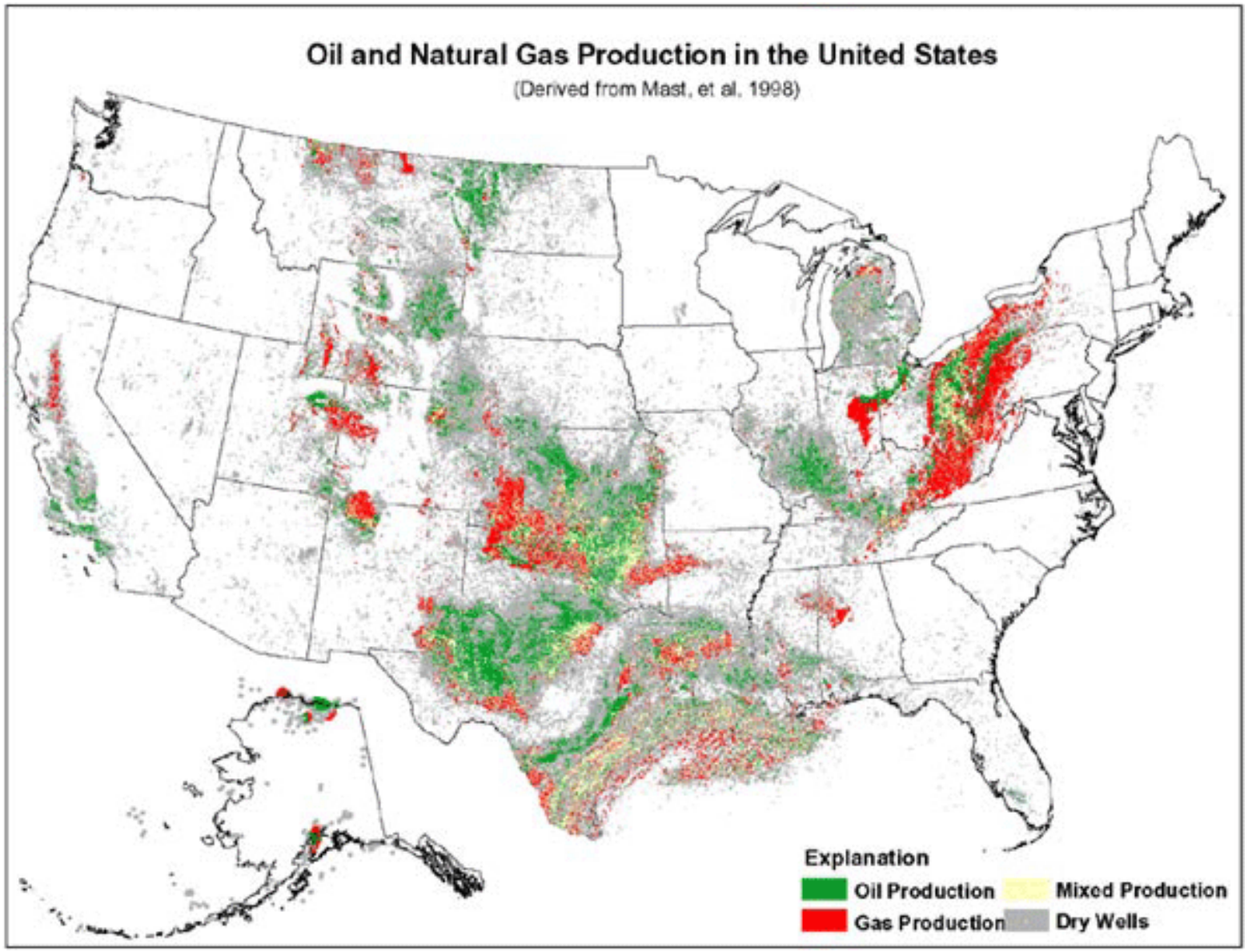
Topics Covered

- The base of opportunity and expertise
- Short history
- Current status
- What's next
- Over the horizon
- Why substantial CO_2 could come from CCUS

The Base of Opportunity and Expertise

- Oil and gas industry mature and seasoned
- Resources well known
- Regional and Federal regulatory structures in place
- Infrastructure very robust and dynamic

US Conventional Oil and Gas Areas

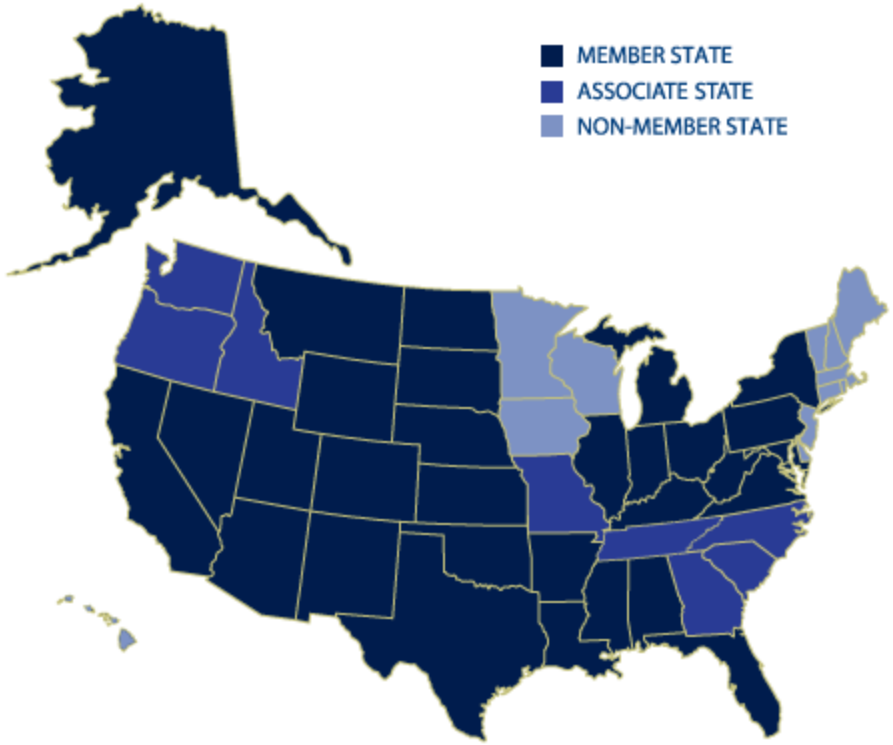


Interstate Oil and Gas Compact Commission

Source: http://www.iogcc.org/member-states

Member States

Our membership is comprised of the governors of oil and gas producing states, as well as appointed representatives. Mouse over a state below for more information.



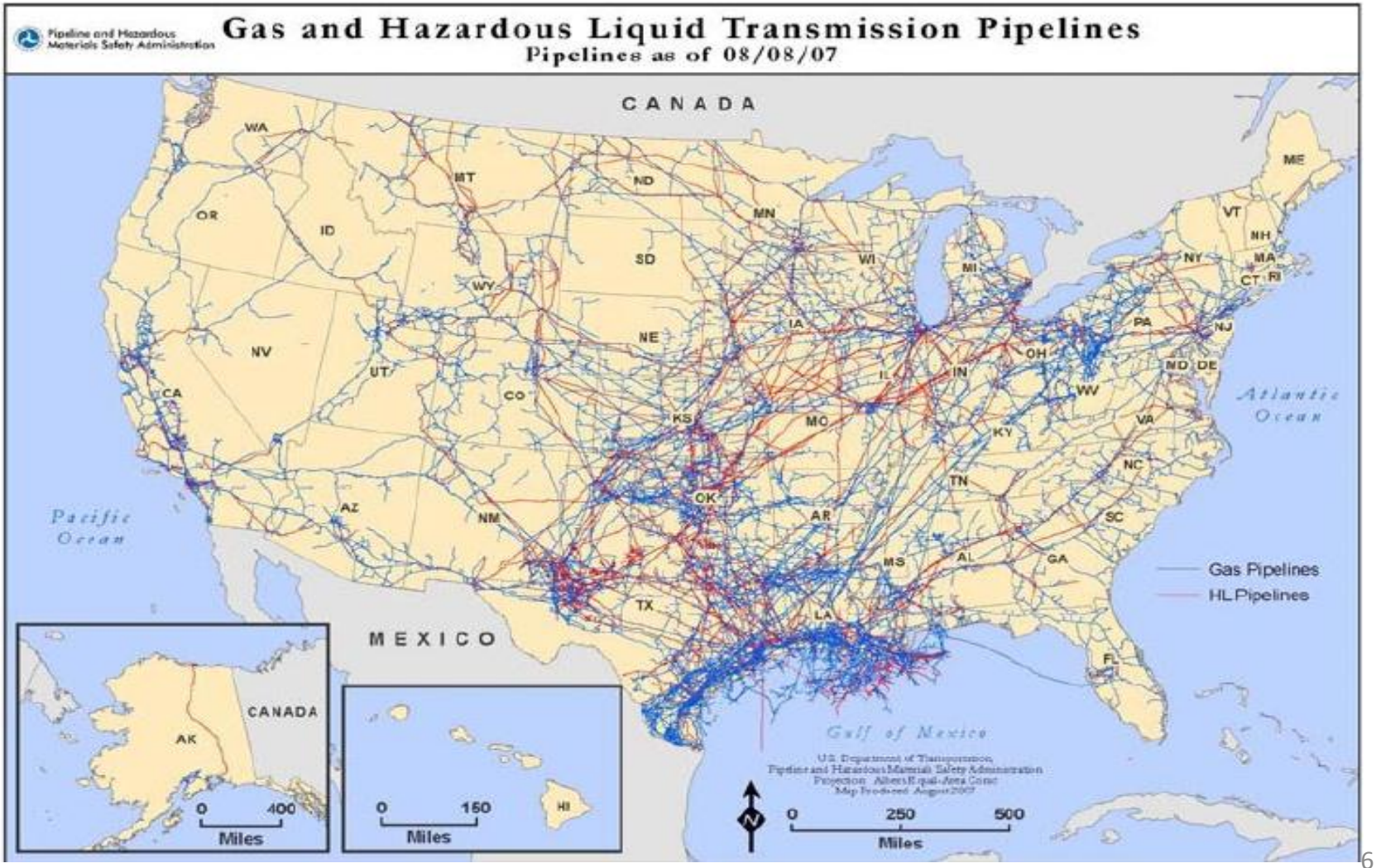
INTERNATIONAL AFFILIATES

- Alberta
- British Columbia
- Egypt
- Republic of Georgia
- New Brunswick
- Newfoundland and Labrador
- Nova Scotia
- Saskatchewan
- Venezuela
- Yukon

OTHER AFFILIATES

- U.S. Department of Energy
- U.S. Department of the Interior
- U.S. Environmental Protection Agency
- Federal Energy Regulatory Commission
- National Association of Regulatory Utility Commissioners

480,000 Miles of Natgas - Oil and HL Pipelines-Constantly Expanding

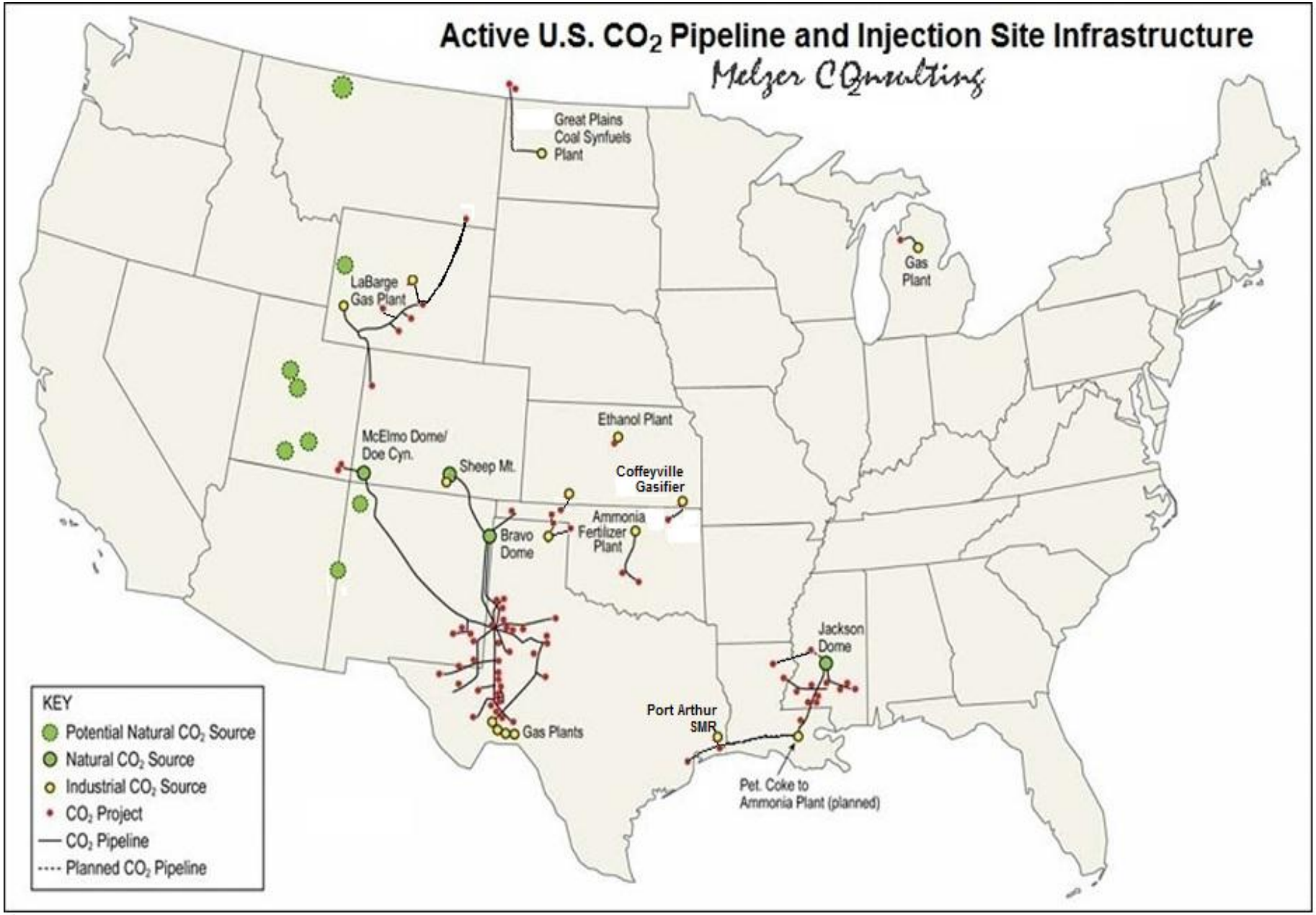


Short History

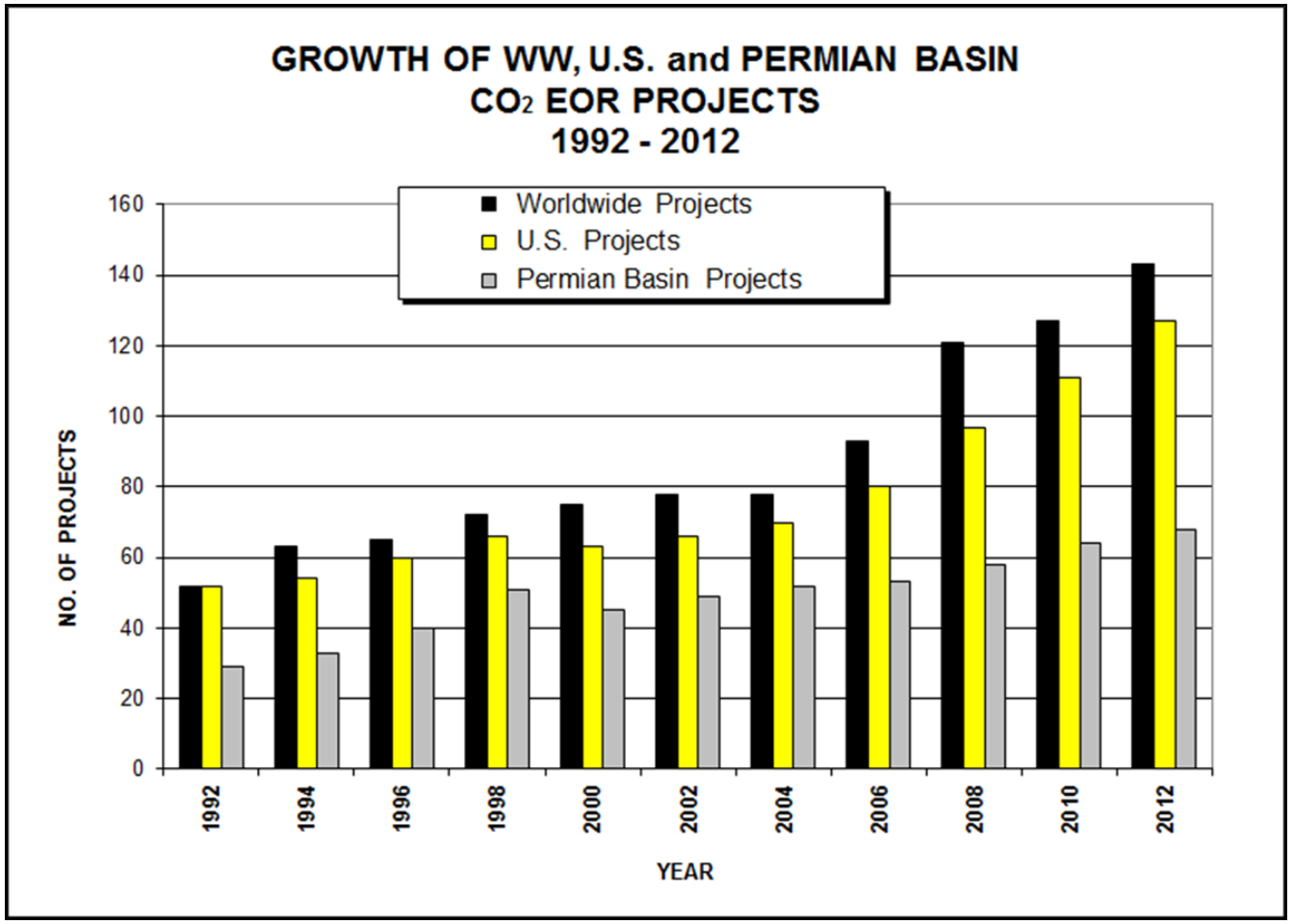
- The first patent for CO_2 EOR was granted in 1952
- Texas Railroad Commission reports the first three projects were initiated in Osage County, Oklahoma between 1958 and 1962.
- First large scale demonstrations in early 1970s: example–SACROC (1972)
- Oil Embargo of 1973 accelerated US developments and incentives
- Since then, projects implemented in multiple countries: Canada, Hungary, Turkey, Trinidad, France, Italy, China, Brazil etc.
- Under consideration for fields in North Sea, UAE, Indonesia, Saudi Arabia, Abu Dhabi, Venezuela, Egypt, Iran, etc.
- Current Status in US
- –120+ projects
- –Accounts for ~350,000 bbls of oil per day in production
- –CO_2 supply ~ 3 billion cubic feet per day
- –Significant growth in the Gulf Coast & Permian Basin
- –42 Billion barrels of recoverable reserves in the US-conventional CO_2-EOR with ROZ in addition to this
- Future? CO_2-EOR in unconventional (shale) oil plays

Current Status

- Well understood immediate opportunities
- Robust and dynamic CO_2 infrastructure
- Seasoned players
- 40yrs of working practical experience
- CO_2 for EOR regulatory structure in prime production areas established
- Significant contribution to US domestic oil production

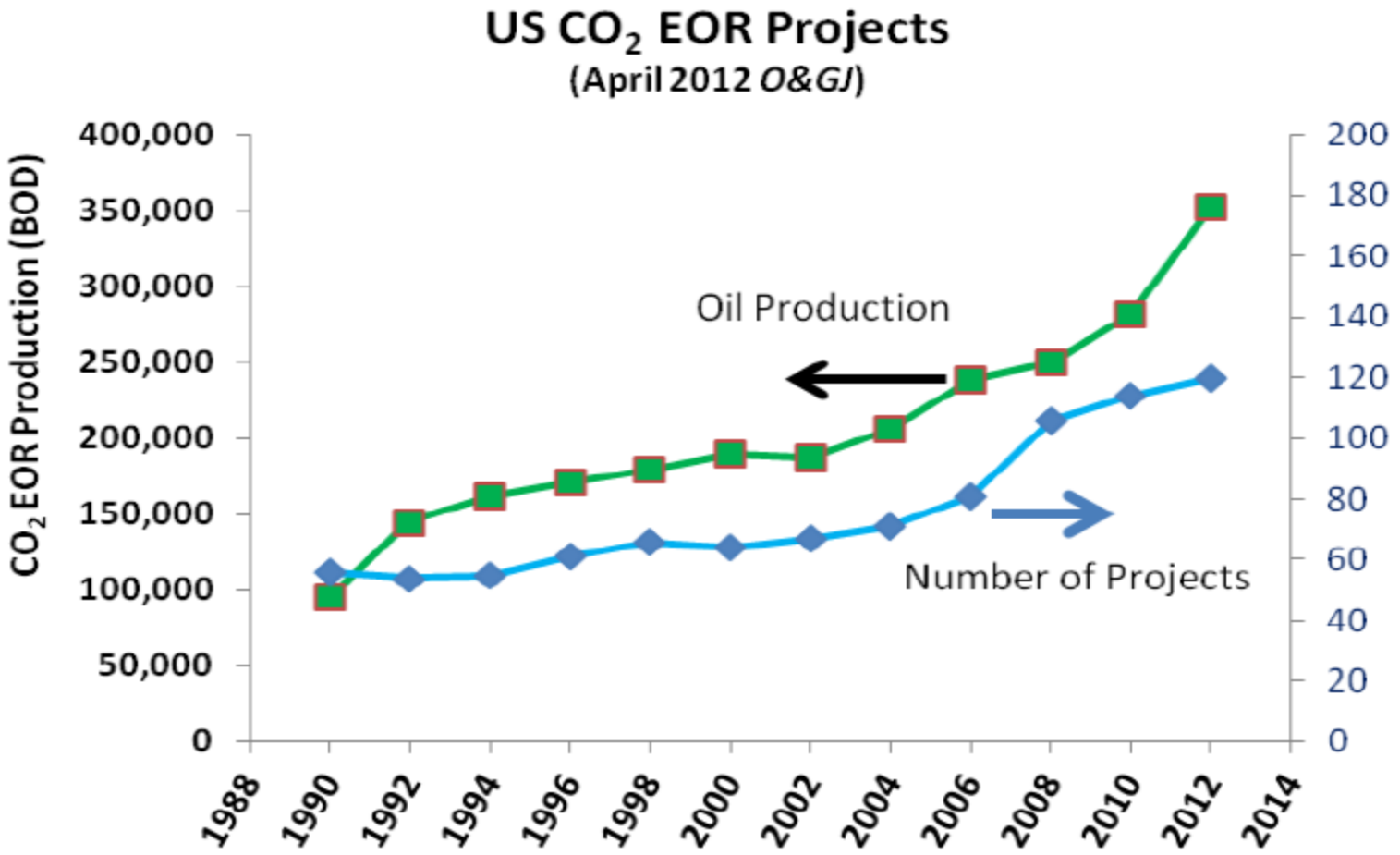

Active U.S. CO_2 Pipeline and Injection Site Infrastructure
Melzer CO_2nsulting
Great Plains Coal Synfuels Plant
LaBarge Gas Plant
Gas Plant
McElmo Dome/ Doe Cyn.
Sheep Mt.
Ethanol Plant
Coffeyville Gasifier
Ammonia Fertilizer Plant
Bravo Dome
Jackson Dome
Gas Plants
Port Arthur SMR
Pet. Coke to Ammonia Plant (planned)
KEY
Potential Natural CO_2 Source
Natural CO_2 Source
Industrial CO_2 Source
CO_2 Project
CO_2 Pipeline
Planned CO_2 Pipeline

CO_2 EOR Project Growth



Oil & Gas Journal 4/2/12 & UTPB Petroleum Industry Alliance

CO_2 EOR Projects and Oil Production

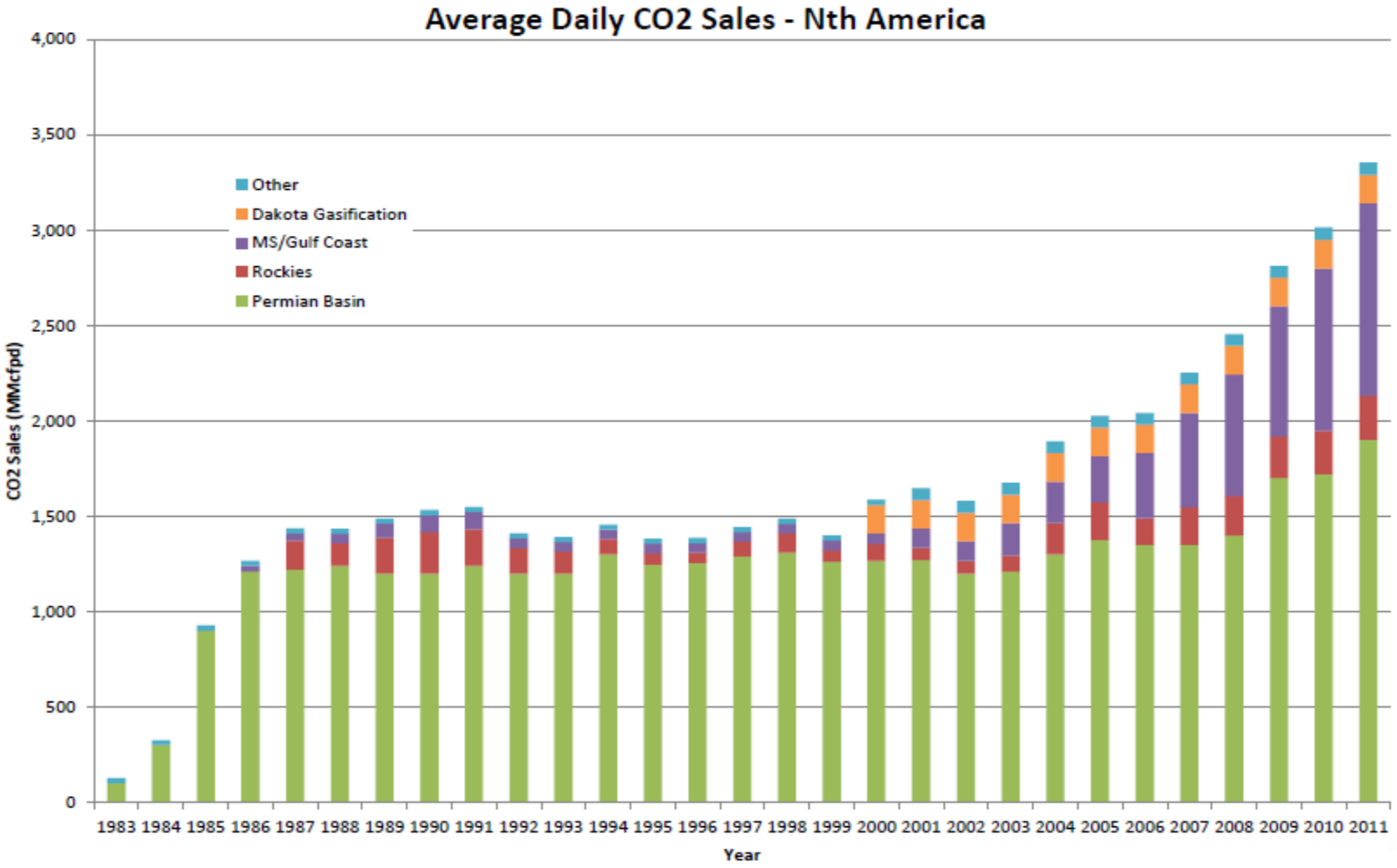


CO_2 Sales for EOR

http://www.uwyo.edu/eori/_files/docs/co2midland-2012-final.pdf

Doll et al., 2009 3rd Wyoming Annual CO2 Conf.; Murrell, 2012 6th Wyoming Annual Co2 Conf.; Denbury Resources 2011 Annual Report; Melzer 2012 6th Wyoming Annual CO2 Conf.; DiPietro et al., 2012

Historic CO2 Sales



What's Being Developed Now?

- Residual Oil Zone
- Steve Melzer and Bob Trentham will cover later

ROZ-Residual Oil Zone

http://www.aogr.com/index.php/magazine/cover-story/goldsmith-landreth-unit-other-roz-co2-eor-projects-give-legacy-fields-new-l

- Exactly how huge remains an open-ended question for now, but Bob Trentham adds that everyone agrees the numbers are very, very big. ***"The residual oil zones may contain 100 billion barrels of oil in place and 10 billion-30 billion barrels of recoverable oil, and some argue that it could be even larger,"*** he states, referencing the fact that the Permian Basin has cumulatively produced 30 billion barrels since the discovery well was drilled more than 80 years ago. ***"Every additional 1 percent increment of reserves that we can recover is an additional 1 billion barrels of oil. That is the size of the prize."***

Over the Horizon

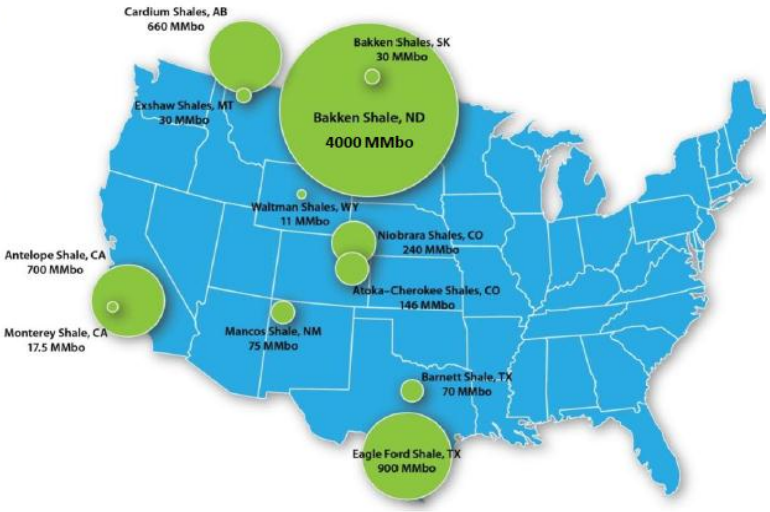
- North Dakota's Energy and Environment Research Center (EECR) is conducting current work on CO_2 for EOR in Bakken Shale
- Indications are likely favorable can also safely retain or store the CO_2 as well

CO_2-EOR in Shale Oil/Bakken

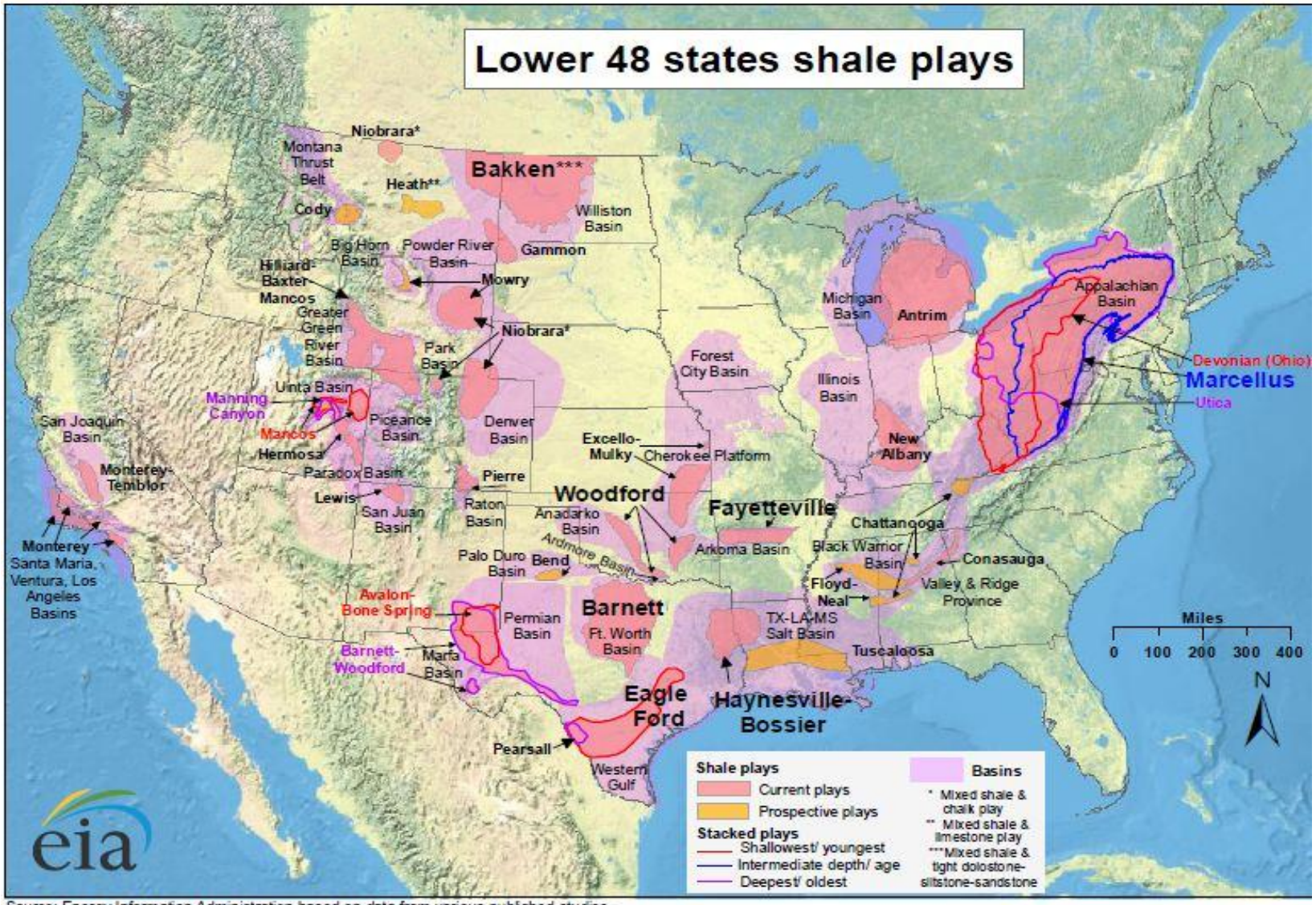
Ultimate Impact to North Dakota

Technologic & Economic Impact

- ND Dept. of Mineral Resources estimates that OOIP for the Bakken and Three Forks combined in North Dakota is approximately 170 billion barrels (Bbbls).
- If the application of CO_2 for EOR can improve recovery by just 1.1%, that improvement would translate to an additional 1.87 Bbbls of oil production.
- Assuming an average oil price of $80/bbl, this would equate to approximately $150 billion worth of oil.
- CO_2 EOR could prolong the life of the Bakken oil fields by decades.
- Results may be applicable to tight oil plays across the United States in Texas, Montana, California, Mississippi, Ohio, etc.



US Shale Plays - Unconventional Oil &Gas



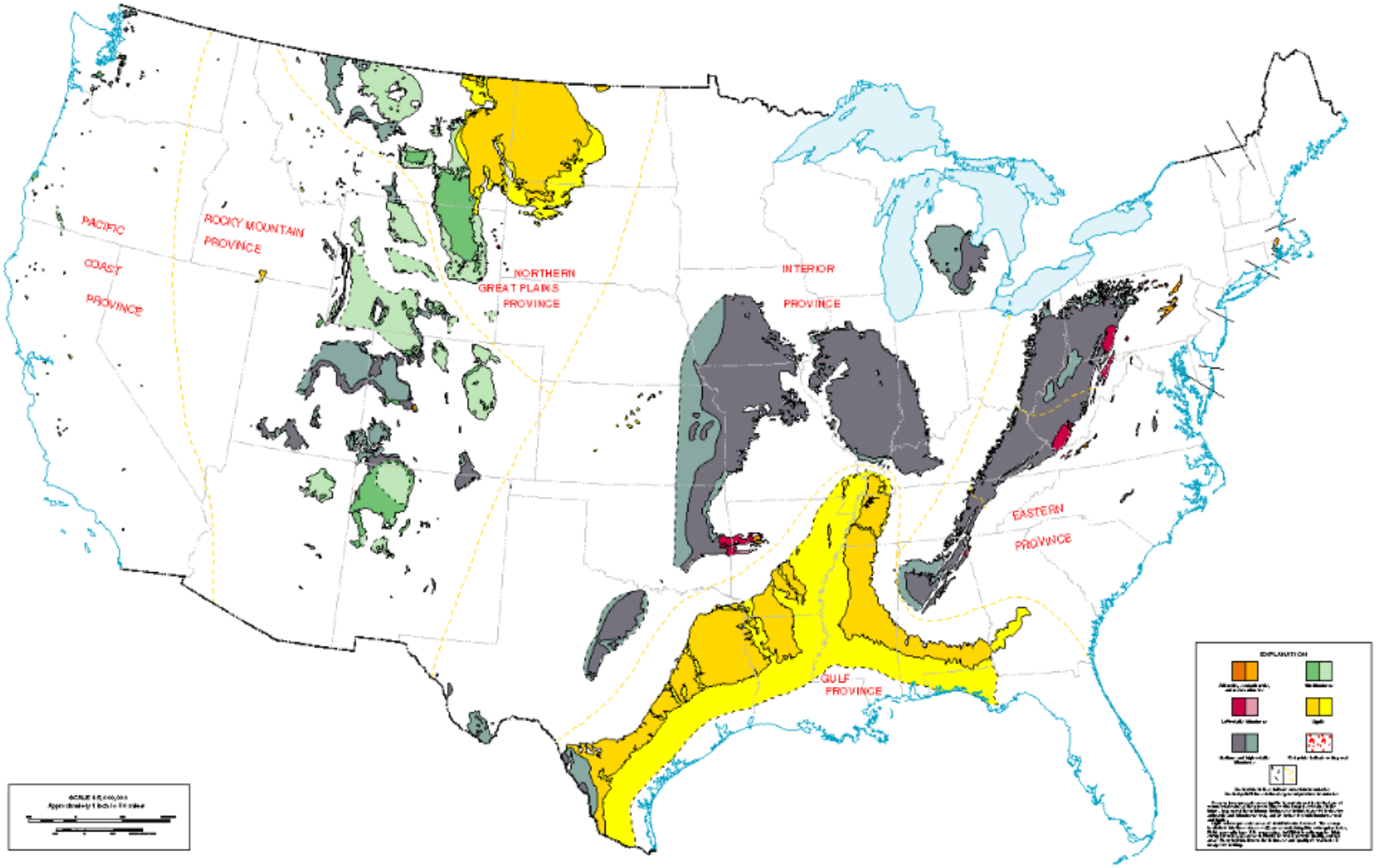
Source: Energy Information Administration based on data from various published studies.
Updated: May 9, 2011

Why Substantial CO_2 Could Come From CCUS

- Some CO_2-EOR regions limited by supply
- New developments in ROZ and shale will push demand higher
- US coal resources very valuable and owners want to monetize this resource
- Export as a raw commodity or utilize domestically in the power generation, petrochemical, CTL or Syngas industries?

US Coal Resources

Source: http://pubs.usgs.gov/of/1996/of96-092/Comp/main.gif

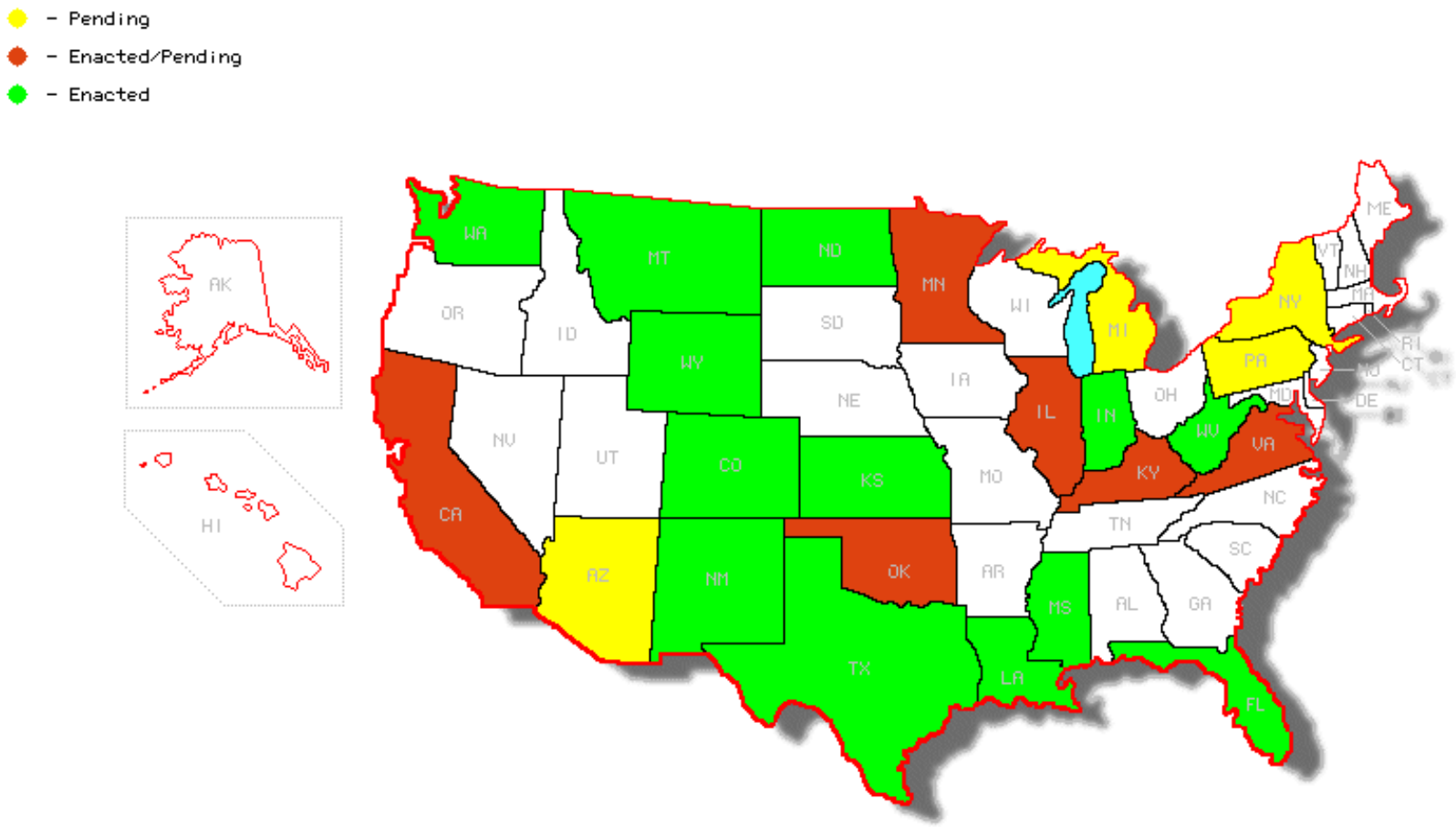


US CCUS-Power and Industrial Projects

- DOE's John Lytinski will cover this later

States with CCUS Legislation

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



Questions & Thank You!

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