The Status of CO_2 EOR Using Both Natural and Anthropogenic CO_2

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Introduction to the U.S. CO_2 EOR Survey

Introduction to the U.S. CO_2 EOR Survey

Download available at www.adv-res.com

- **The U.S. CO_2 EOR Survey provides an annual update of incremental oil recovery and project status for all CO_2 EOR projects in the U.S.**
- This survey was borne out of the original Oil & Gas Journal biennial EOR Survey, published from 1986 to 2014.
- Advanced Resources International updates the survey each year with the help of Steve Melzer, Lon Whitman, and verification from project operators.
- **The survey is a free public resource hosted at adv-res.com**

Introduction to the U.S. CO_2 EOR Survey

- The U.S. CO_2 EOR Survey includes 20 data points for each project, including:
  - Operator name, location, and field area/well counts,
  - Reservoir name and lithology,
  - Reservoir characteristics, including volumetric data and oil gravity,
  - Total and enhanced oil production.

Operator Data

Reservoir Type

2020 Operator	Field	State	Start Date	Area (ac)	Prod. Wells	Inj. Wells	Pay Zone	Lithology
Amplify Energy Operations	Lost Soldier	WY	5/1/1989	1,795	46	64	Tensleep	SS
Amplify Energy Operations	Lost Soldier	WY	5/89	490	19	29	Darwin-Madison	S/LS-Dolo.
Amplify Energy Operations	Lost Soldier	WY	6/96	80	9	14	Cambrian	SS
Amplify Energy Operations	Wertz	WY	10/86	1,540	35	52	Tensleep	SS
Amplify Energy Operations	Wertz	WY	3/99	890	16	26	Darwin-Madison	S/LS-Dolo.
				4,795	125	185		

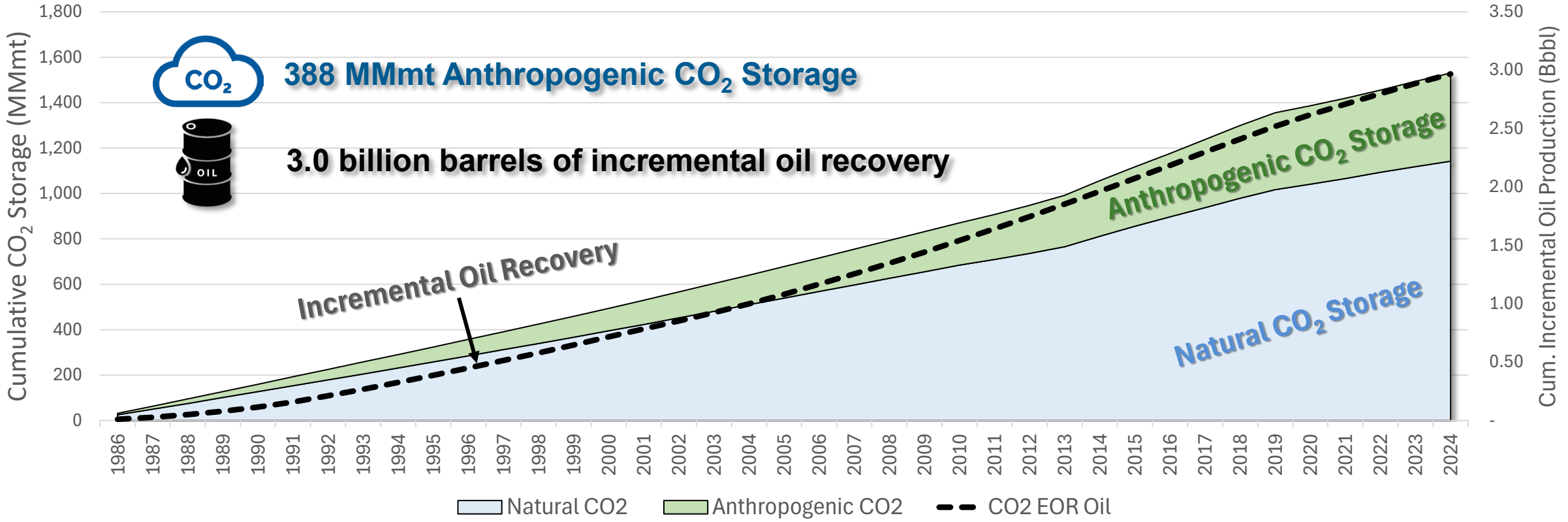
Reservoir Characteristics

Production Data

Porosity (%)	Soi (%)	Sor (%)	Avg.Perm. (md)	Depth (ft)	Gravity (Deg API)	Oil Visc. (cp)	Res. Temp. (Deg F)	Prev. Prod.	2020 Tot. Prod. bbl/d	2020 Enh. Prod. bbl/d
11.0	90	-	10	5,600	35	1.3	158	WF	913	913
13.0	89	-	4	5,800	35	1.3	162	WF	840	840
12.3	85	-	19	6,500	35	1.2	174	WF	226	226
10.0	90	-	20	6,600	35	1.2	176	WF	1,217	1,217
10.0	89	-	5	6,800	35	1.0	180	WF	668	668
									3,864	3,864

Cumulative CO_2 Storage and Oil Production with CO_2 EOR

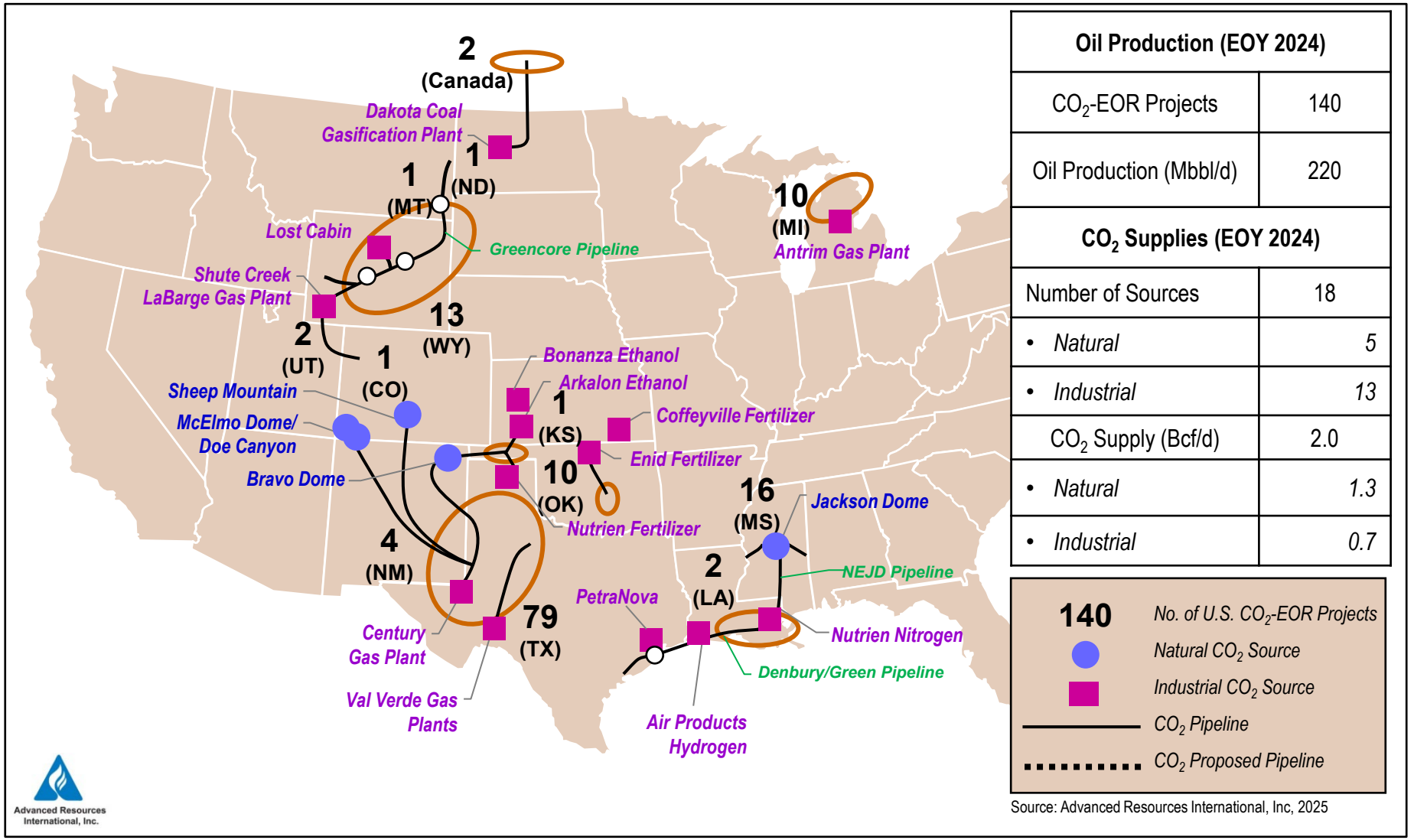
- Since 1986, CO_2 EOR projects in the U.S. have stored nearly 390 billion tons of anthropogenic CO_2 (1.5 billion tons total) and produced 3.0 billion barrels of incremental oil.
- **This is an average of over 10 million tons of anthropogenic CO_2 storage per year for the last 38 years.**



The 2024 U.S. CO_2 EOR Survey Results

The Status of CO_2 EOR in the U.S. (EOY 2024)

- In 2024 **140 projects** produced **220,000 bbl/d** (80.3 MMbbl total) of incremental oil.
- **2.0 Bcf/d of CO_2** (38 MMmt total) was purchased for CO_2 EOR injection and permanent storage.
- This is a CO_2 utilization rate of about 8.9 Mcf/bbl (0.47 mt/bbl).



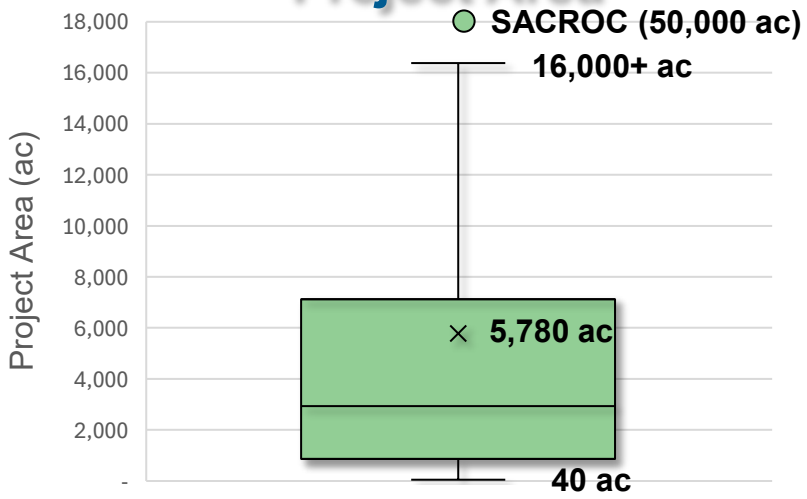
Oil Production (EOY 2024)	
CO_2-EOR Projects	140
Oil Production (Mbbl/d)	220
CO_2 Supplies (EOY 2024)	
Number of Sources	18
• *Natural*	*5*
• *Industrial*	*13*
CO_2 Supply (Bcf/d)	2.0
• *Natural*	*1.3*
• *Industrial*	*0.7*

140 *No. of U.S. CO_2-EOR Projects*
Natural CO_2 Source
Industrial CO_2 Source
CO_2 Pipeline
CO_2 Proposed Pipeline

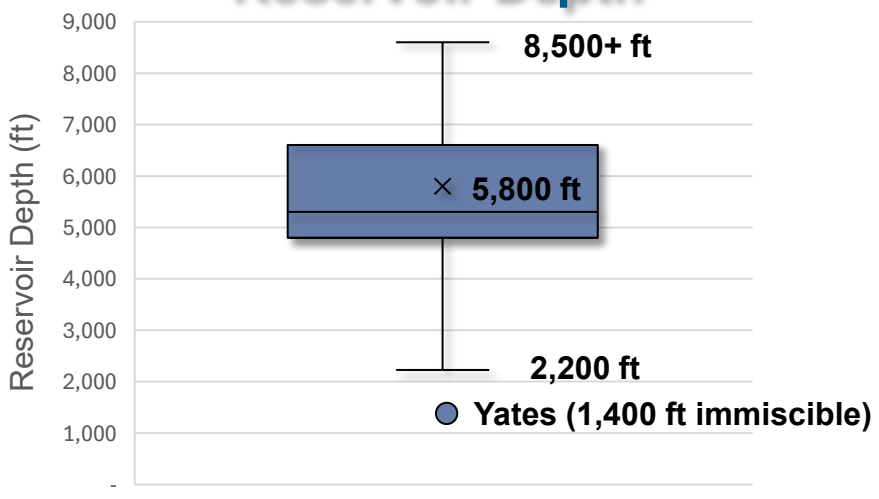
Source: Advanced Resources International, Inc, 2025

U.S. CO_2 EOR Reservoir Statistics

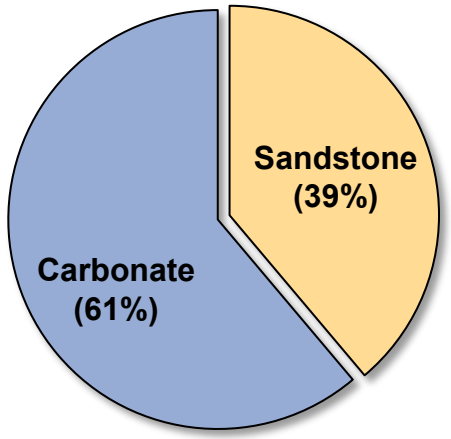
Project Area



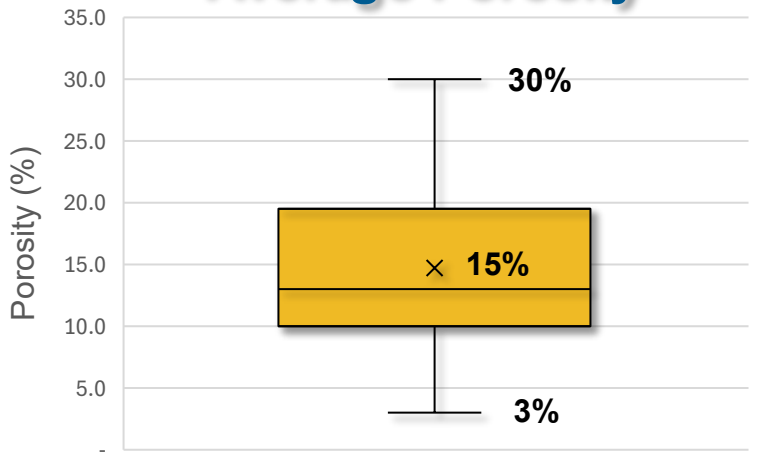
Reservoir Depth



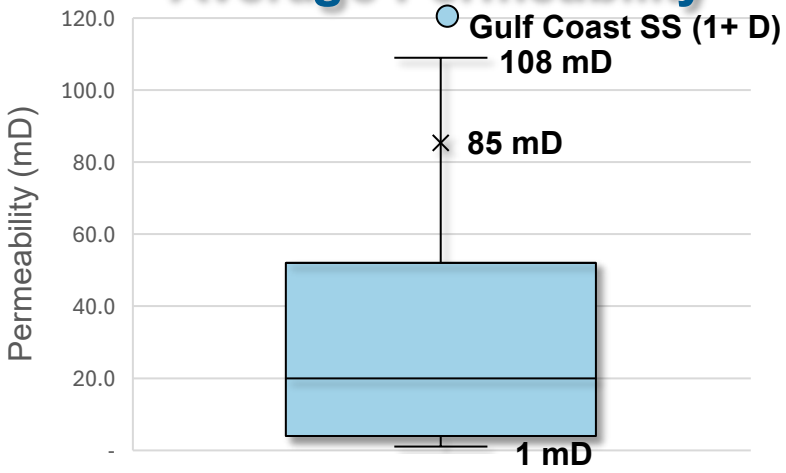
Lithology



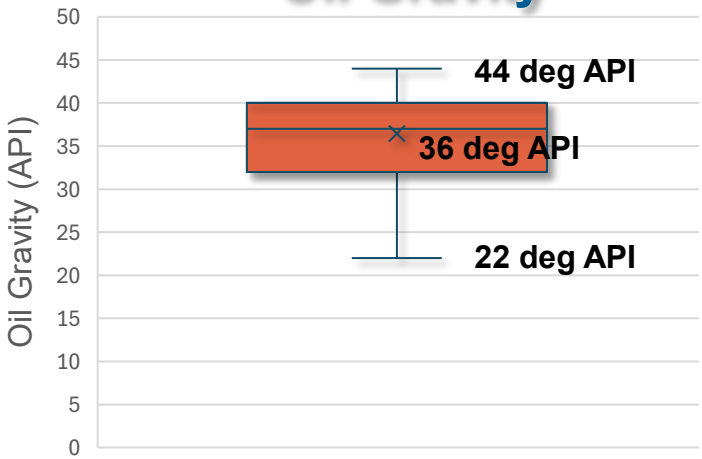
Average Porosity



Average Permeability



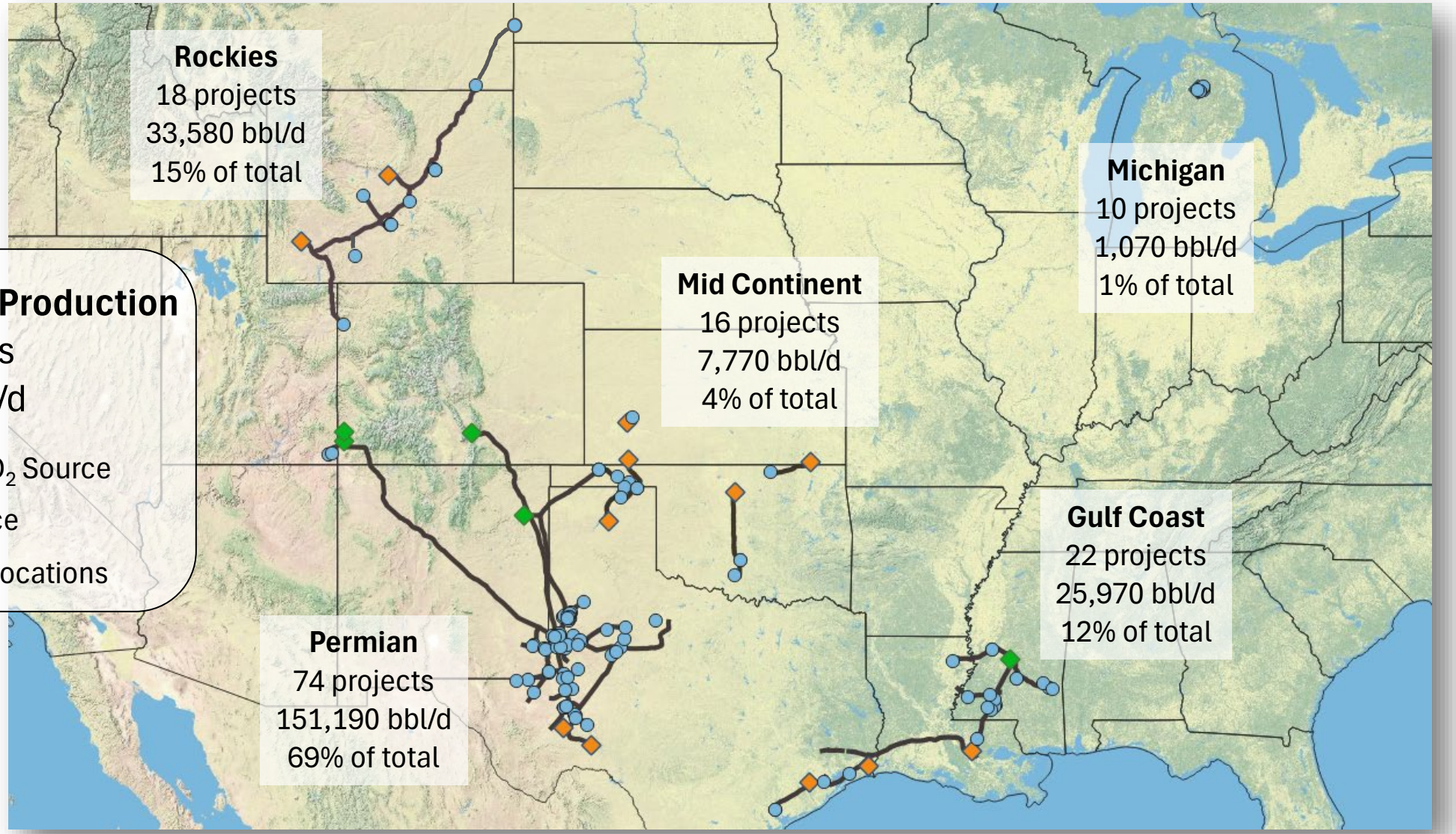
Oil Gravity



2024 CO_2 EOR Fields and Enhanced Oil Production

2024 US CO_2 EOR Oil Production
140 projects
219,580 bbl/d

- Anthropogenic CO_2 Source
- Natural CO_2 Source
- CO_2 EOR Project Locations



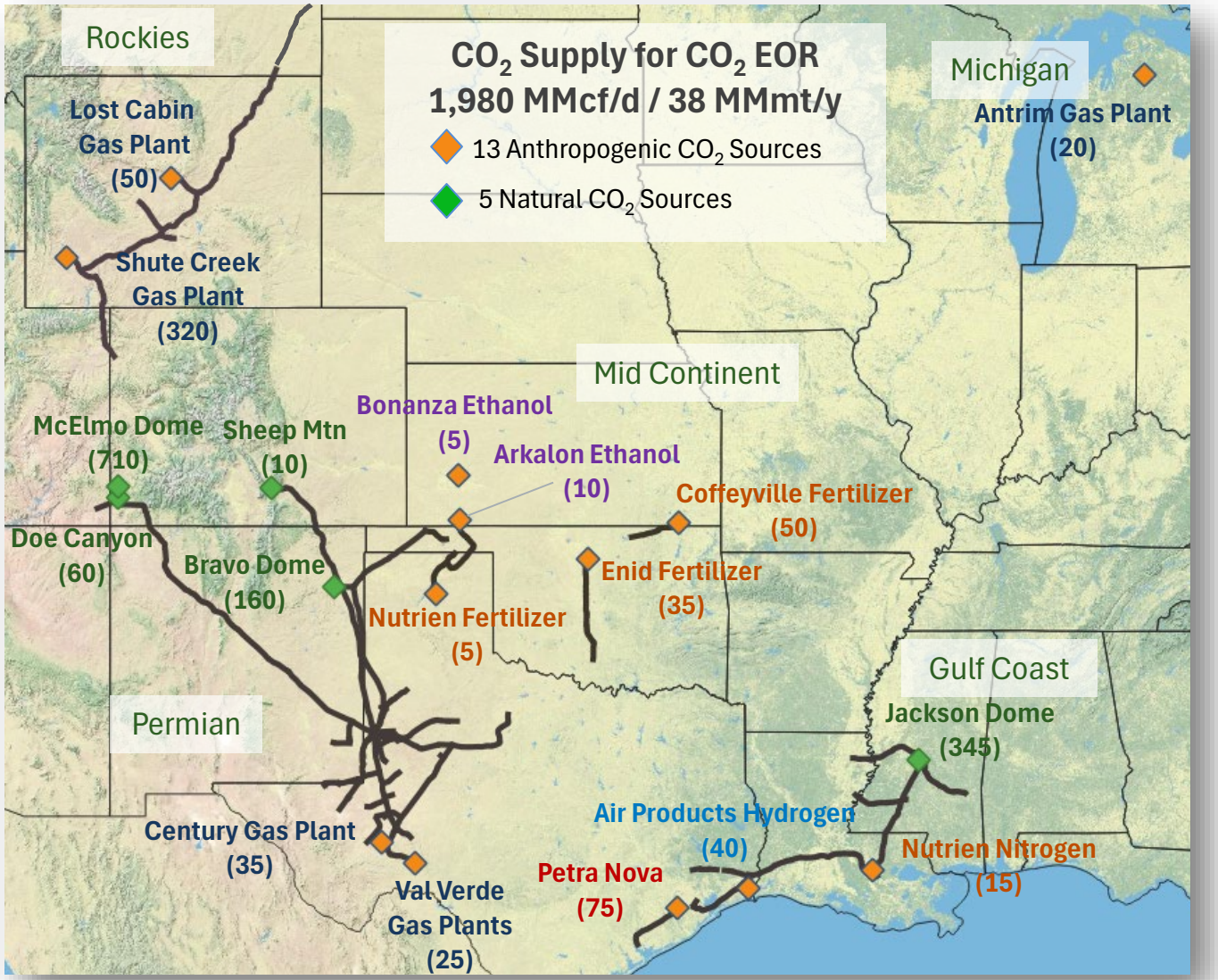
2024 CO_2 EOR Project Operators

Region	Projects	Operators	Operator Names
Permian (TX, NM)	74	15	Apache, Capturepoint, ConocoPhillips, Fasken, George R Brown, Kinder Morgan, Maverick, Morningstar, Occidental, Orla Petco, Q Natural Resources, Sabinal Energy, Scout, Two P Partners, XTO Energy
Gulf Coast (MS, LA, TX)	22	4	Exxon/Denbury, Hilcorp, Tellus, TMR Exploration
Rockies (WY, UT, MT, CO)	18	5	Amplify Energy, Contango, Exxon/Denbury, Elk Petroleum, Scout
Mid Continent (OK, KS)	16	4	Capturepoint, Daylight Petroleum, Maverick Energy, Petro Santander
Mid West (MI)	10	1	Core Energy
Total	140	29	

- There are a total of 25 CO_2 EOR operators in the U.S.
- Patriot Production sold TwoFreds to Q Natural Resources in mid 2024.
- Maverick Energy sold to Diversified in early 2025.
- Capturepoint, Denbury/Exxon, Maverick (Diversified), and Scout operate CO_2 floods in multiple regions.

2024 CO_2 Supply for CO_2 EOR

CO_2 EOR Region	CO_2 Source Type	CO2 Supply (MMcf/d)	(Mt/y)
Permian	Natural	900	17.3
	Anthropogenic	60	1.2
	Total	960	18.4
Gulf Coast	Natural	345	6.6
	Anthropogenic	130	2.5
	Total	475	9.1
Rockies	Natural	25	0.5
	Anthropogenic	370	7.1
	Total	395	7.6
Mid Continent	Natural	25	0.4
	Anthropogenic	105	2.0
	Total	130	2.5
Michigan	Natural	-	-
	Anthropogenic	20	0.4
	Total	20	0.4
2024 Total	**Natural**	**1,295**	**24.8**
	Anthropogenic	**685**	**13.2**
	Total	**1,980**	**38.0**



Natural CO_2 Source Reserves

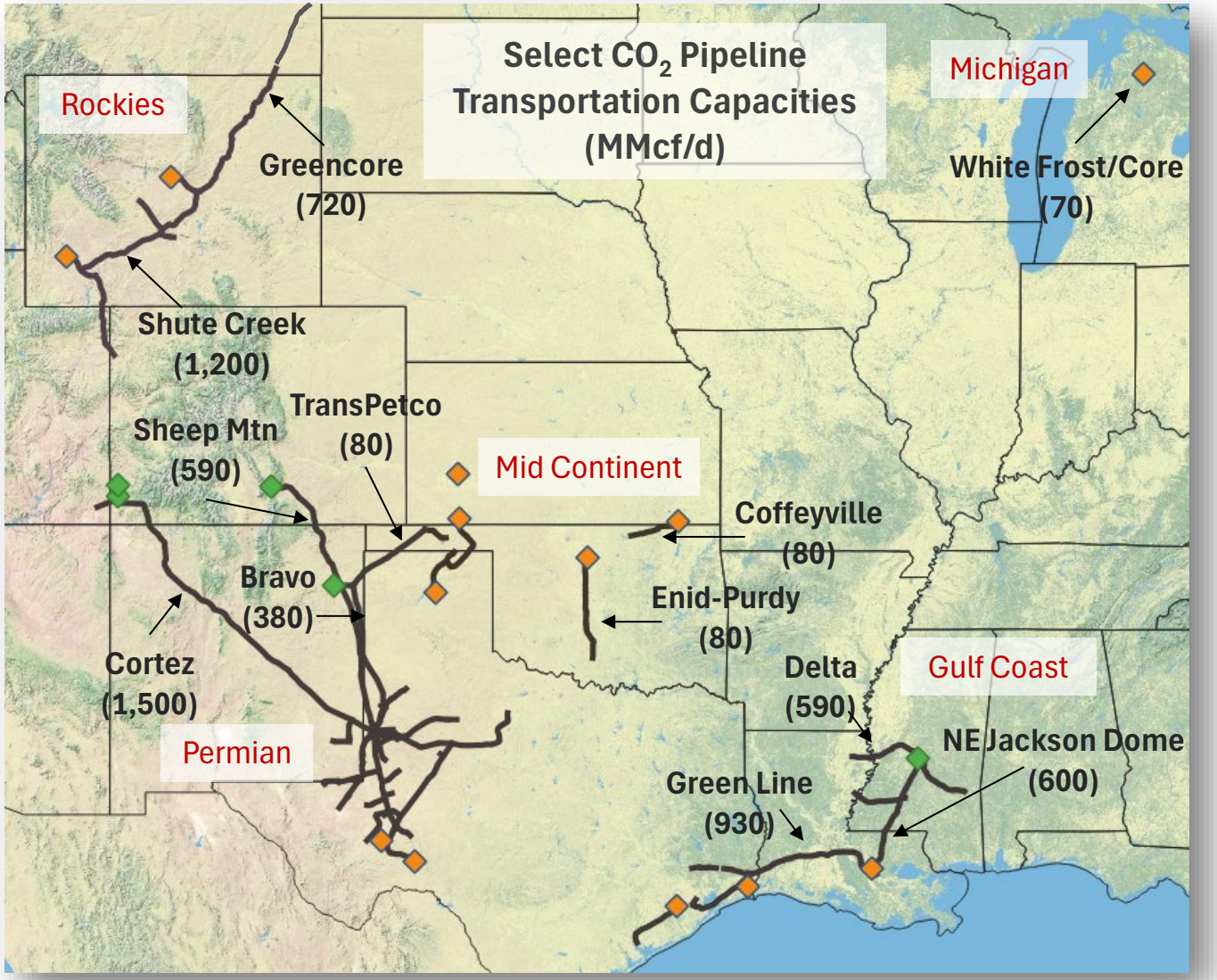
- Natural CO_2 supplies for CO_2 EOR have been flowing for over 40 years.
- Estimated remaining reserves of the five natural sources is 692 MMmt.
- At the current supply rate of 24.4 MMmt/y, natural sources have an estimated 28 years of supply remaining.

Region	Company	Source	2023 Reserves (MMmt)	Current Supply (MMmt/y)	Remaining Supply Years at Current Rate
Permian Basin	Kinder Morgan	McElmo Dome	249	13.7	18
	Oxy	Bravo Dome	231	2.7	86
	Oxy	Sheep Mountain	1.8	0.2	9
	Kinder Morgan	Doe Canyon	31	1.2	26
Gulf Coast	Exxon/Denbury	Jackson Dome	179	6.6	27
TOTAL			**692**	**24.4**	**28**

2024 CO_2 Pipeline Infrastructure

Region	CO_2 Pipelines (mi)	Transportation Capacity	
		(MMcf/d)	(MMmt/y)
Permian	2,610	5,190	99.7
Gulf Coast	840	2,410	46.3
Rockies	900	2,640	50.7
Mid Continent	475	360	6.9
Michigan	10	70	1.3
Total	**4,835**	**10,670**	**205**

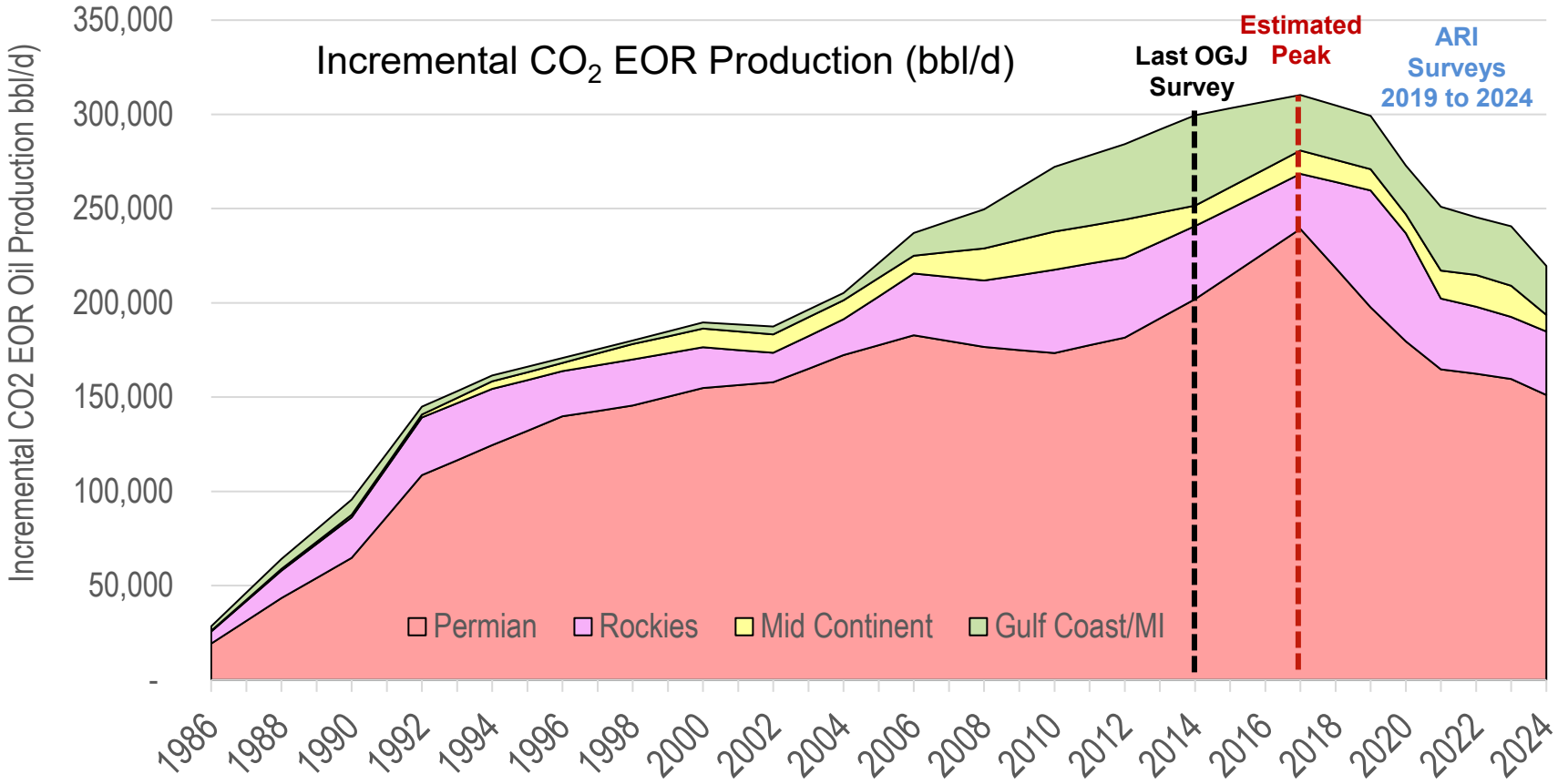
- **New CO_2 EOR project developments could leverage available CO_2 pipeline transportation capacity**



U.S. CO_2 EOR Production History (1986 to 2024)

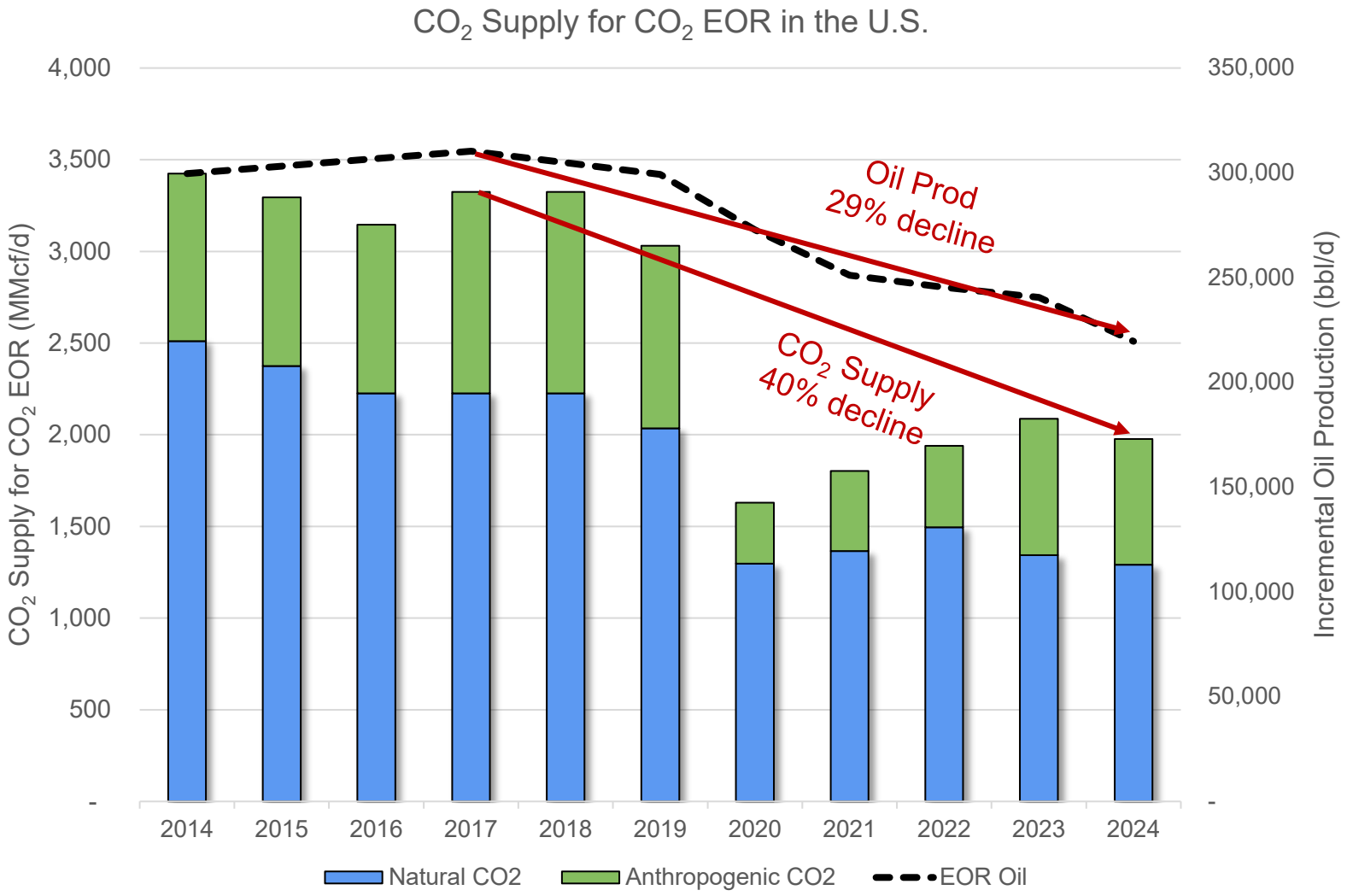
- Incremental oil production from CO_2 EOR reached a peak of about 315,000 bbl/d in 2017.
- The 2024 U.S. CO_2 EOR Survey shows production declined ~9% from 2023 to 2024.

Survey Year	Incremental Production (bbl/d)	Production Change (%)
2014	273,000	
2017	315,000	+15%
2019	299,000	-5%
2020	273,000	-9%
2021	250,000	-8%
2022	245,000	-2%
2023	241,000	-2%
2024	220,000	-9%



Trend of CO_2 Supplies for CO_2 EOR (EOY 2023)

- CO_2 supply for CO_2 EOR declined from over 3 Bcf/d in 2017 to about 2 Bcf/d in 2024.
- Reduced supply is due to decreased natural CO_2 production for CO_2 EOR and decreased CO_2 supplies from natural gas processing.
- **CO_2 EOR oil production has decreased 29% over the same time period, but has been sustained through CO_2 recycling and infill drilling.**



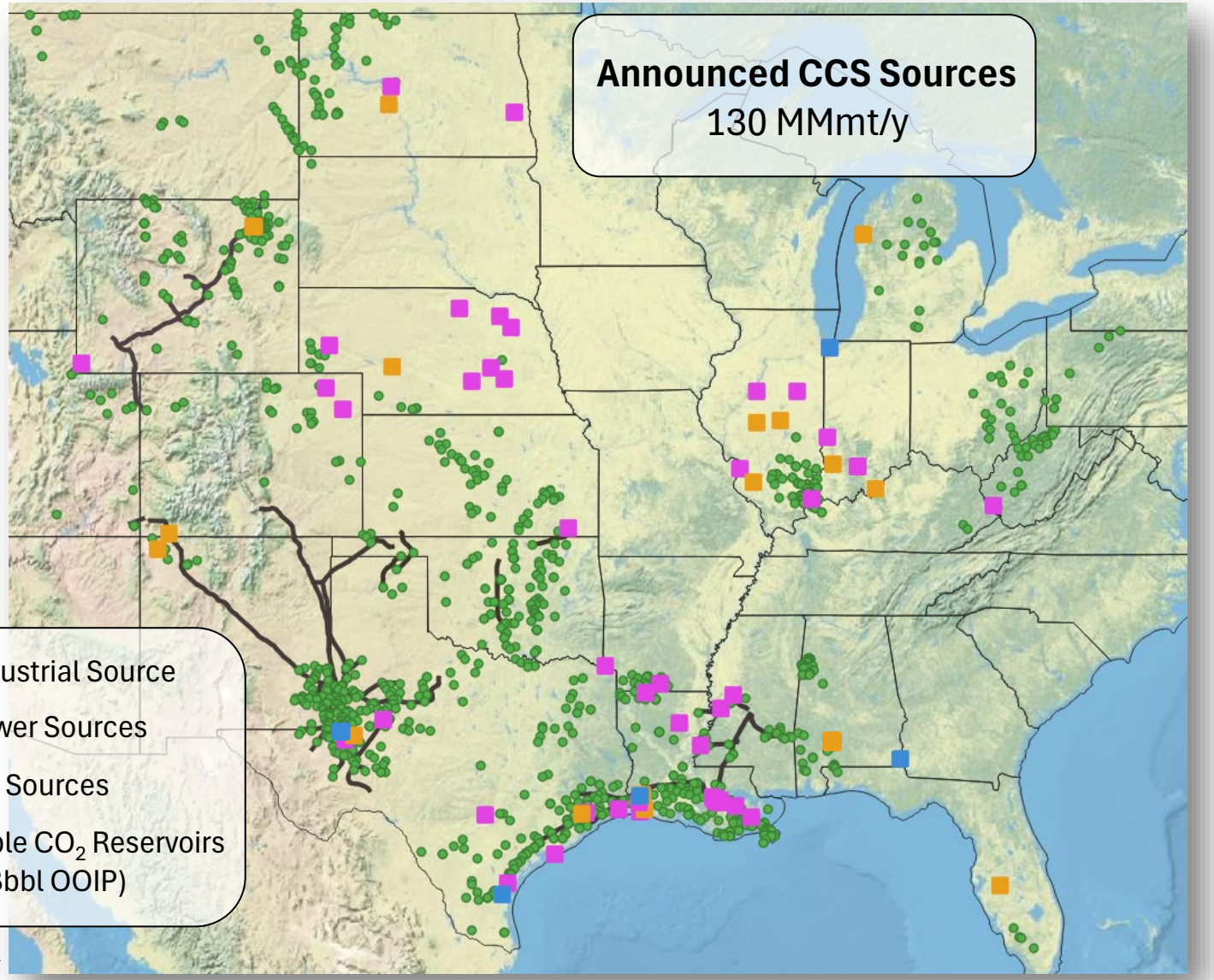
Outlook for Anthropogenic CO_2 Supplies for CO_2 EOR

CCS May Lead the Way for Increased CO_2 Supplies for EOR

- CO_2 EOR in the U.S. has always been limited by the availability of high-quality, reliable sources of CO_2 delivered to oil fields at pressure.
- No new natural sources are likely to come online due to long transportation requirements and no incentive for storage through 45Q credits.
- New CO_2 supplies for CO_2 EOR will likely:
  - Come from anthropogenic CO_2 sources
  - Be sourced within 30 miles of the CO_2 EOR field
  - Include low capture cost gas processing plants/ammonia/ethanol sources until capture costs improve or higher oil prices are sustained
- **A significant number of CO_2 capture projects have been announced that could supply CO_2 for CO_2 EOR.**

Announced CO_2 Capture Projects

- There are 71 announced CCS projects* coming online by 2031 that have total CO_2 capture capacity of 130 MMmt/y.
- The map shows the locations of over 1,300 reservoirs viable for miscible CO_2 EOR
- These reservoirs have over 275 BBbl of OOIP**
- These capture sources could use CO_2 EOR for CO_2 storage if CCS permitting delays persist or project costs continue to rise.



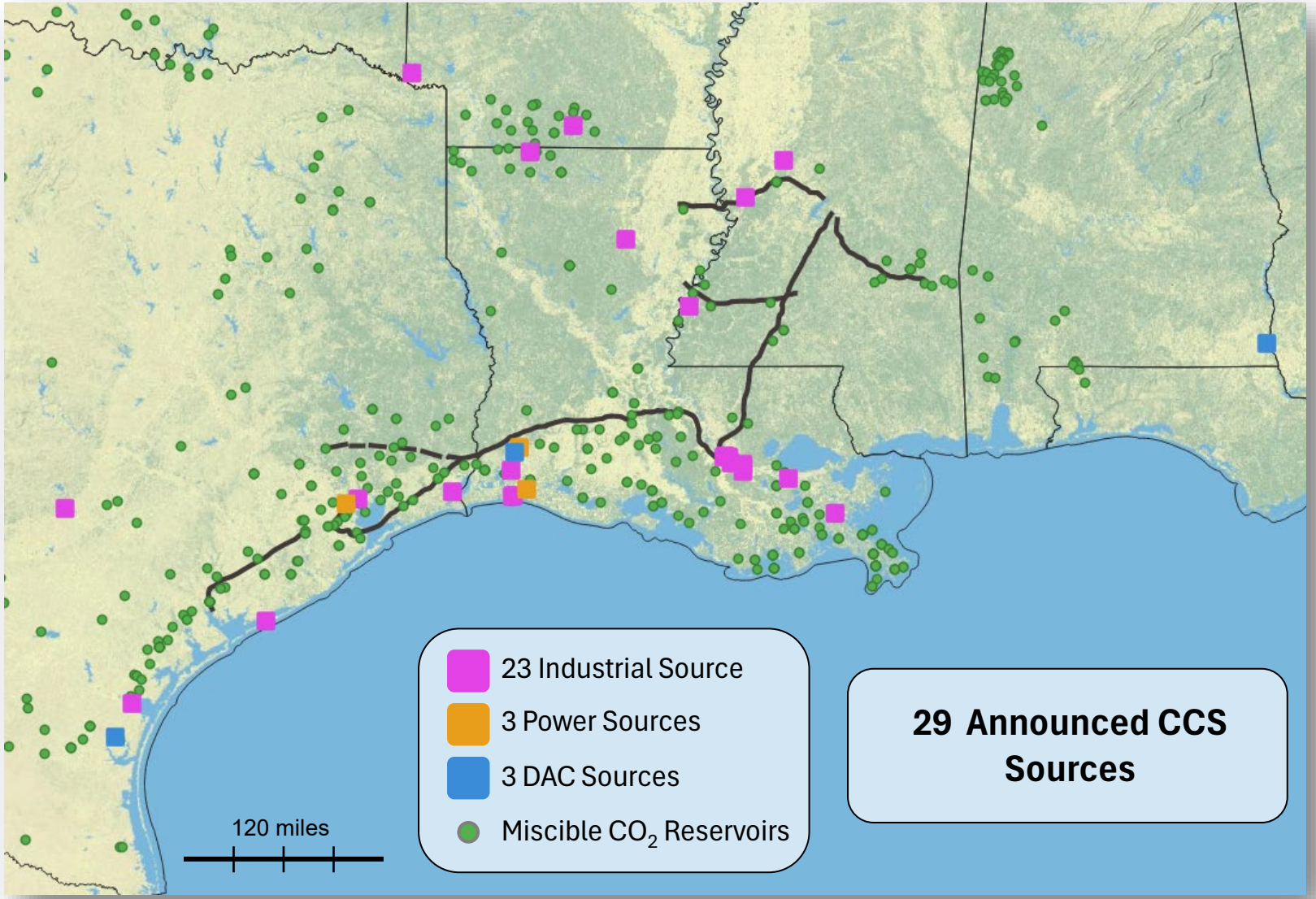
*Including projects with federal DOE support and commercial capture projects

**Est. 15% EUR using CO_2 EOR is 41+ BBbl, CO_2 Storage is 19 Bmt using a 9 mcf/bbl utilization factor

Gulf Coast CO_2 Sources and Miscible CO_2 EOR Potential

- There are 29 announced anthropogenic CCS sources in the Gulf Coast region near miscible CO_2 oil reservoirs.
- Many of these CO_2 sources and oil reservoirs are within ~30 miles of existing CO_2 transportation infrastructure.

Gulf Coast CCS Sources	Number of Sources	Est. CO_2 Supply (MMmt/y)
DAC	3	2.5
Ammonia	7	22.0
Hydrogen	4	17.6
Gas Processing	5	5.9
Natural Gas Power	3	12.0
Other	7	10.3
Total	**29**	**70.3**

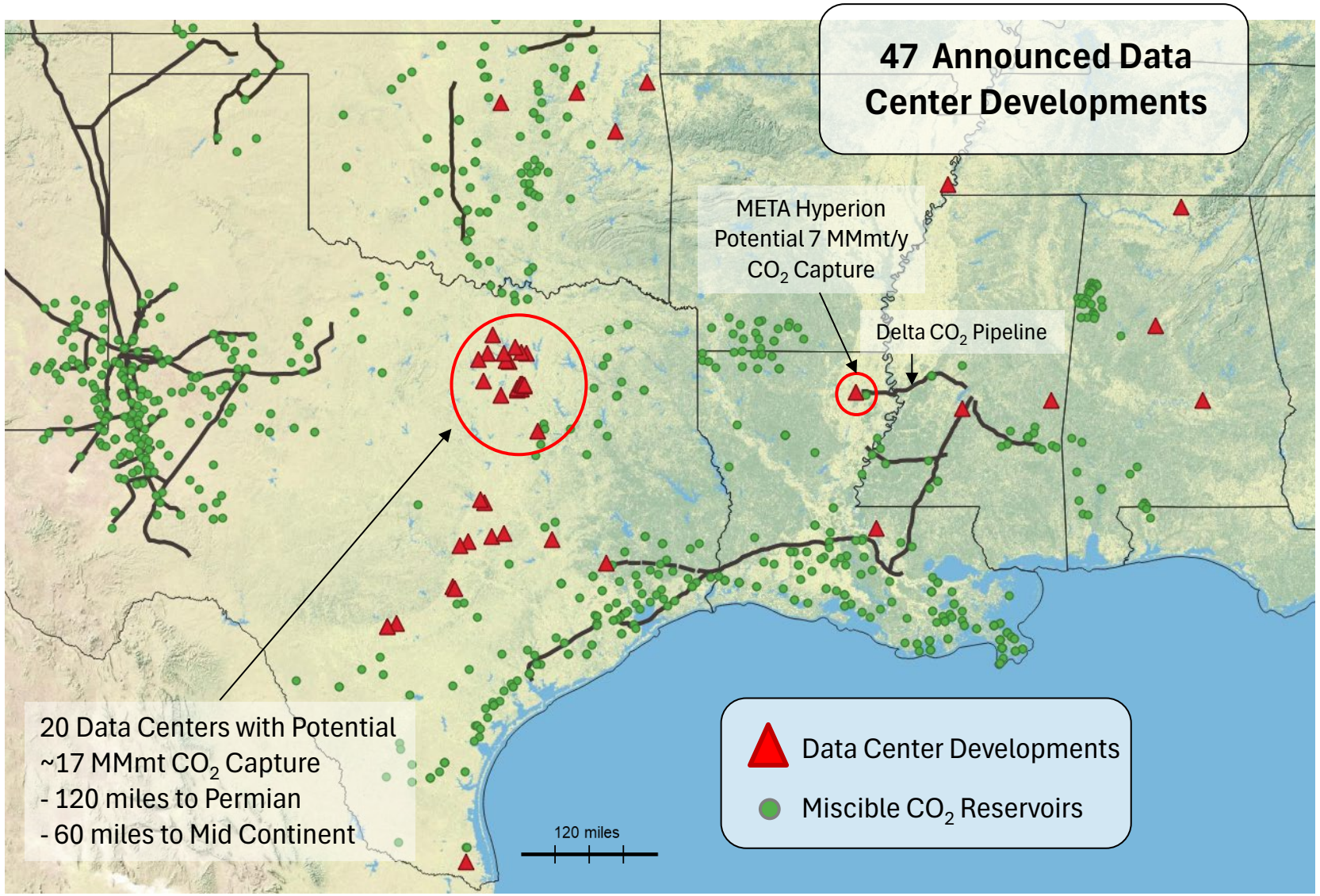


U.S. Data Center Development

- Data Center power consumption is projected to increase four-fold from 2023 to 2030, requiring 606 Twh, or ~12% of U.S. power demand.
- Roughly 25% of new hyperscale data centers over 500 MW of capacity expect to include behind-the-meter natural gas turbine power generation to reduce grid reliance.
- The Meta announced plans for integrated CCS at their $10B Holly Ridge, LA project.
- Meta contracted with Entergy to build three gas power facilities totaling 2.3 GW.
- However, the data center industry is racing to market, largely without considering CCUS for on-site power generation, requiring future retrofits.
- **Encouraging early CO_2 capture and siting near CCUS resources is a potential policy opportunity for data center regulation.**

Potential for CCUS with Data Centers in the Southeast

- There are 47 announced data center projects (Aug '25) with power demands of 100+ MW.
- These 47 data center projects represent CO_2 capture equivalent of 54.7 MMmt per year, or 2,850 MMcf/d
- This is almost twice the volume of total CO_2 supplied for CO_2 EOR in 2024.
- Many of these projects are located near miscible reservoirs and CO_2 transportation infrastructure, like the Meta Hyperion project.

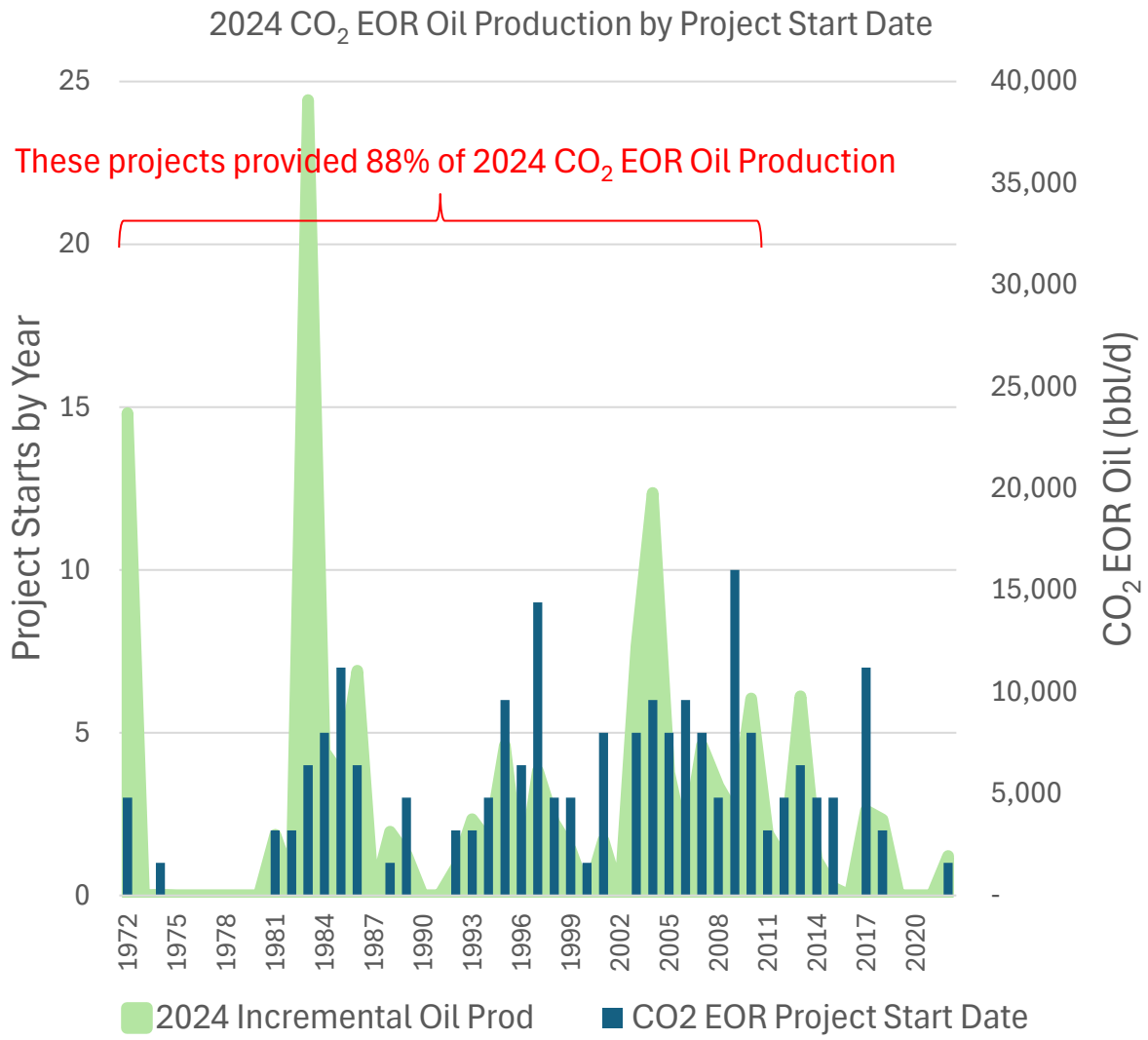


*Using a conversion factor of 0.4 mt/Mwh for CO_2 emissions

The CO_2 EOR Value Proposition

CO_2 EOR Offers Pathways to U.S. Energy Security

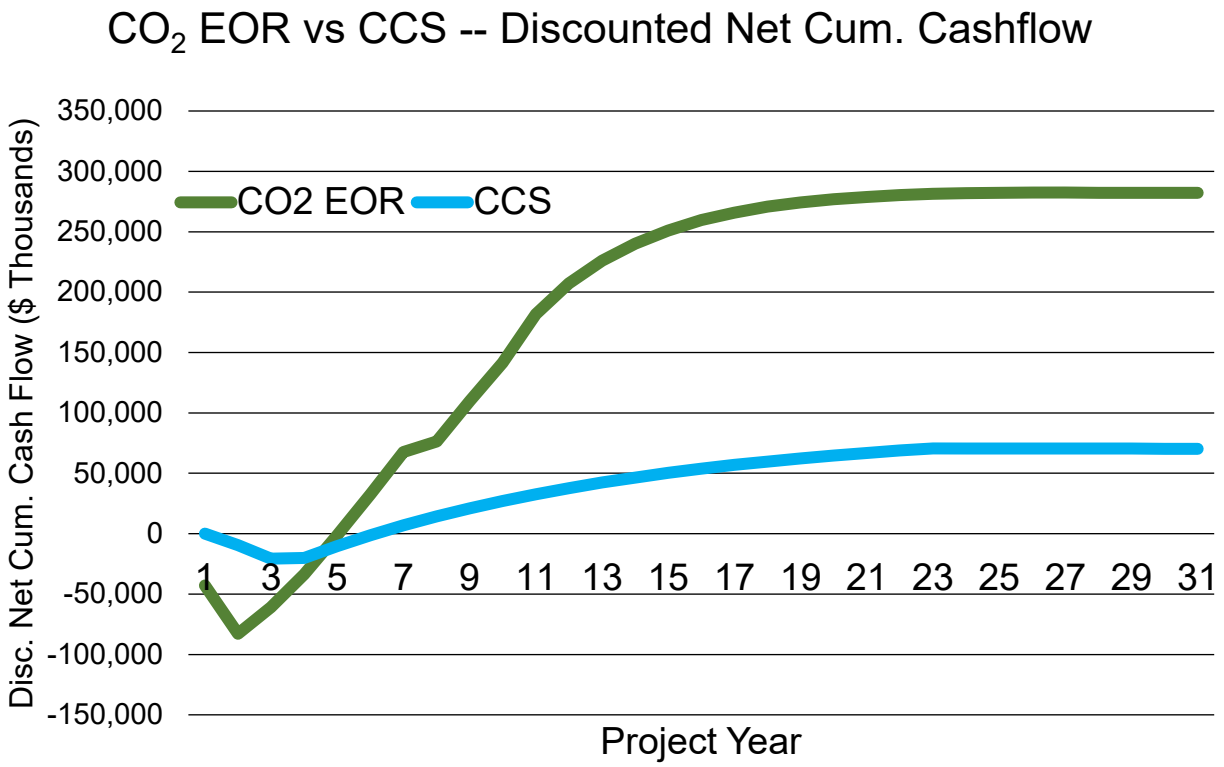
- Federal energy policy is shifting heavily to U.S. energy dominance and security.
- CO_2 EOR can recover ~15% of remaining OIP without the need for additional greenfield exploration and development.
- Investment in CO_2 EOR supports decades of oil production -- 88% of CO_2 EOR oil produced in 2024 came from projects between 15 and 52 years old.



CO_2 EOR Provides Long-Term Positive Investment Returns

- CO_2 EOR requires significant start-up capital but offers competitive economics to CCS and tight oil investments.
- Benefits of CO_2 EOR vs CCS:
  - Oil production offers continued positive revenue generation if tax credits disappear.
  - CO_2 EOR can have a shorter payback period with immediate oil revenue and faster development
  - CO_2 EOR is a mature, tested technology that offers secure geologic storage of CO_2
  - Able to scale CO_2 EOR projects with more dynamic development/management options.

Example cash flow comparison for a CCS and CO_2 EOR project storing ~15 MMmt over ~25 years

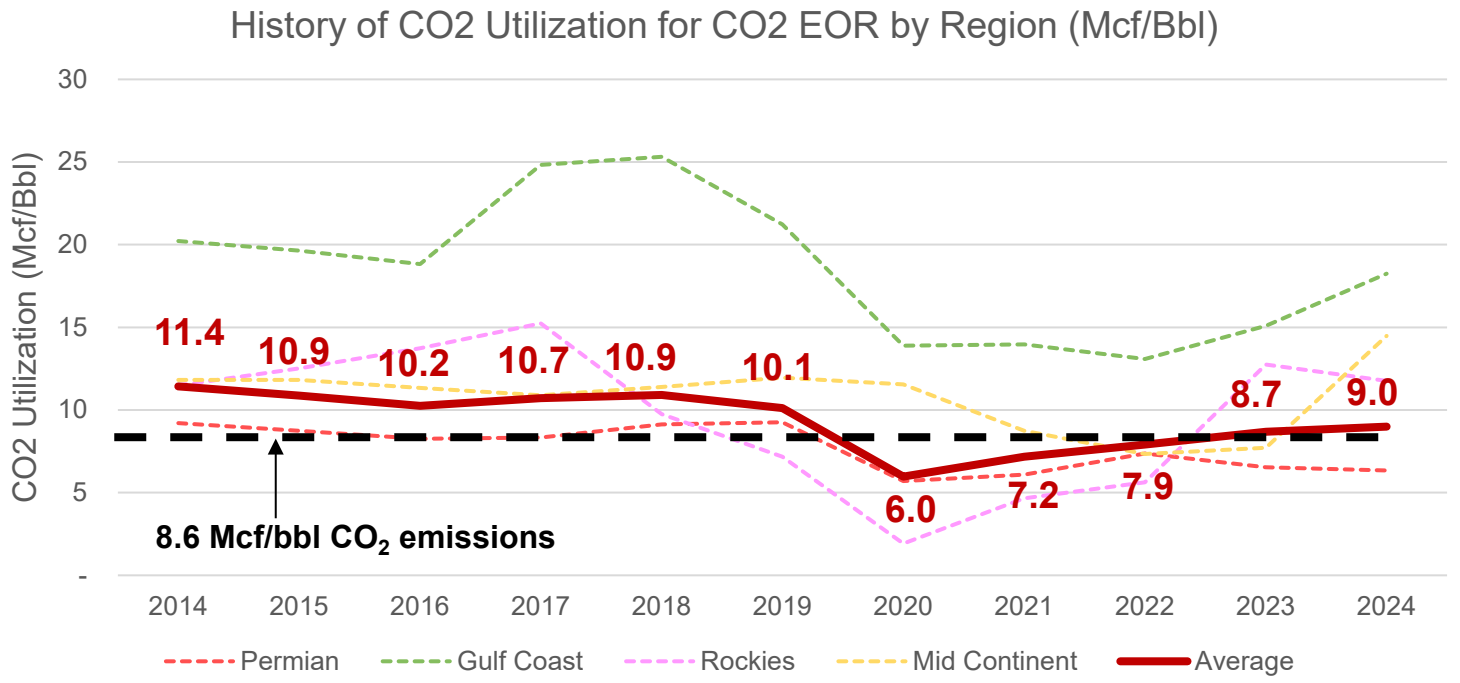


CO_2 EOR Offers Carbon Storage Solution and Low Carbon Fuel Production

- Oil produced with CO_2 EOR has a lower carbon intensity than conventional oil produced in the U.S. or overseas.
- The market for low-carbon fuels is emerging, which will benefit from new LCA work to establish the scope and baseline emissions for CO_2 EOR.

CO_2 Emissions Per Barrel of Conv. Oil

Activity	CO_2 Emissions	
	(mt/bbl)	(Mcf/bbl)
Production	0.007	0.1
Transportation	0.004	0.1
Refining	0.024	0.5
Consumption	0.416	7.9
Total	**0.451**	**8.6**



Championing Unconventional CO_2 EOR

- There is significant opportunity to expand CO_2 EOR in the U.S. using brownfield, conventional reservoirs.
- However, the 50+ years of technical data and results doesn't necessarily apply one-to-one to CO_2 EOR in unconventional reservoirs.
- Significant research, testing, and pilot-scale projects are needed to develop the unconventional CO_2 EOR knowledge base.
- North Dakota and other states are investing in Huff-n-Puff testing, gas composition analysis, microbubble CO_2, and detailed fracture analysis.

State-Level Support for CO_2 EOR

- Wyoming recently created a $250 million CO_2 EOR investment fund to promote CO_2 EOR in the state.
- CO_2 EOR increases state revenues while storing CO_2 and producing low-carbon fuel products.
- States can play a crucial role in supporting mid-sized CO_2 EOR operators
- Patrick Draw and Salt Creek provided over $236 million in state tax revenue from 2009 to 2024 from incremental oil recovery with CO_2 EOR

Field	Incremental Oil Production: 2009-2024, bbl	$/bbl	Severance Tax Rate	Severance Tax Revenue, $
Patrick Draw Field	26,975,278	51.57	6%	83,466,905
Salt Creek Field	49,403,119	51.57	6%	152,863,131
Total	**76,378,397 bbl**			**$236,330,036**

Next Steps

Next Steps

- Ongoing verification of CO_2 EOR Survey data with project operators
- Looking ahead to updating studies/new work on CO_2 EOR resource analysis in the U.S.
- Preparing for EOY 2025 CO_2 EOR Survey compilation starting in May 2026

Thank you!

Questions?

Economic Comparison of Storing Carbon with CCS and CO_2 EOR

Economic Comparison of Storing Carbon with CCS vs CO_2 EOR

- The goal of this exercise was to compare two carbon management projects capable of storing a similar volume of anthropogenic CO_2 (15 million metric tons) in a similar time frame (~25 years).
- Two cost models -- one for a CO_2 EOR project and one for a CCS project -- were built including respective project costs, revenues, and project timing for economic comparison.
- CO_2 injection, oil production, and CO_2 production rates were based on numerical modeling.
- Both cases provided equal incentive to the capturer (net $65/mt) based on the CO_2 costs/revenue.

Economic Assumptions	CO_2 EOR	CCS
Revenue	$80/bbl oil produced	$20/mt CO_2 stored
CAPEX	120 new wells, 60 recompleted wells, well plugging, 10-mile CO_2 trunkline, CO_2 recycling plant, CO_2 gathering pipelines	1 new CO_2 injector, 10 new monitoring wells, surface equipment, 10-mile CO_2 trunkline, site prep/characterization, Class VI permitting
OPEX	Well operation, lifting costs, pipeline operation, CO_2 recycling	Well operation, pipeline operation
Purchased CO_2 Costs	$5/mt (nominal purchase price from capturer)	$0/mt ($CO_2$ provided from capturer at no cost)

Economic Comparison of Storing Carbon with CCS vs CO_2 EOR

- Both projects store ~15 million mt of CO_2 in 23 (CCS) to 26 (CO_2 EOR) years.
- The CO_2 EOR project produces 29 million barrels of incremental oil over 26 years.
- **The CO_2 EOR project has a CO_2 utilization of 9.6 Mcf/bbl (0.51 mt/bbl).**

Carbon Storage Project	CO_2 EOR	CCS
Project Years	26	23
CO_2 Storage (MMmt)	14.7	14.7
Enh. Oil Prod. (MMbbl)	29	--
CO_2 Utilization (Mcf/bbl)	9.6	--