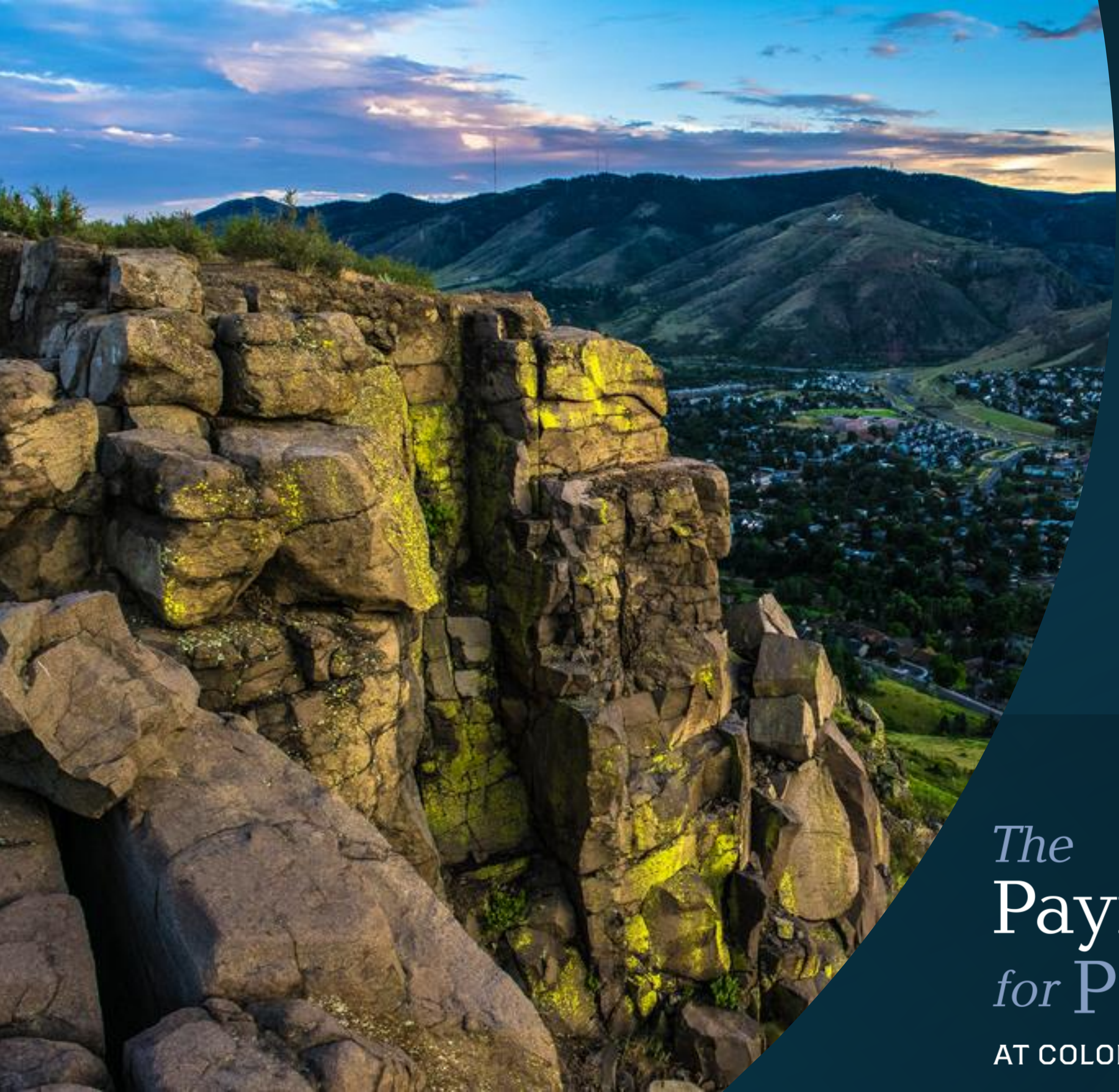


The Inflation Reduction Act, the Budget Bill and the Future of CCUS in the US

Anna Littlefield, September 2025

The Payne Institute for Public Policy
AT COLORADO SCHOOL OF MINES

My Background

2010
Graduated with a B.S. in Geology and a minor in Appalachian Music

2010
Began graduate program at Texas A&M University

2011
Interned with USGS in Boulder, studied 4-mile canyon fire

2012
Interned with Anadarko Petroleum in Houston

2012
Received M.S. in Geology from Texas A&M

2013
Start Fulltime at Anadarko: Worked Hugoton Embayment: workovers, recompletions, helium exploration, land rights/contracts

2015
Worked Onshore Exploration: Sequence Stratigraphy, Gulf Coast, Permian

2017
Transferred to Denver office: Worked DJ Basin Greater Green River Basin Land Grant Asset

2019
Join OXY Low Carbon Ventures Team

2019
OXY Acquires Anadarko

2020
Apply for voluntary severance from OXY

2021
Start PhD program at Colorado School of Mines

Department of Geology and Geological Engineering

2022
Start Position as contract Geochemist at Carbon America

2022
Start as graduate intern at NREL on carbon projects

2022
Start Position as CCUS Program Manager for the Payne Institute for Public Policy

2024
New Position: Low Carbon Energy Program Manager-Geothermal and CCUS

2010 | 2012 | 2013 | 2017 | 2019 | 2020 | 2022 | 2025

The Payne Institute for Public Policy AT COLORADO SCHOOL OF MINES

Presentation Outline

- Why CCUS incentives matter
- What moves the needle?
  - 45Q tax credit
  - Class VI primacy/permitting
  - State levers
  - The role of CarbonSAFE
- What did the 2025 OBBB change?
- Looking forward

Why CCUS Incentives Matter

- CCUS is highly sensitive to policy risk and tax credit value
- 45 Q is the primary U.S. federal driver for point-source CCS and DAC

WASTE

Handled as a public service
Paid for by public funds

COMMODITY

Free markets
dictate the value

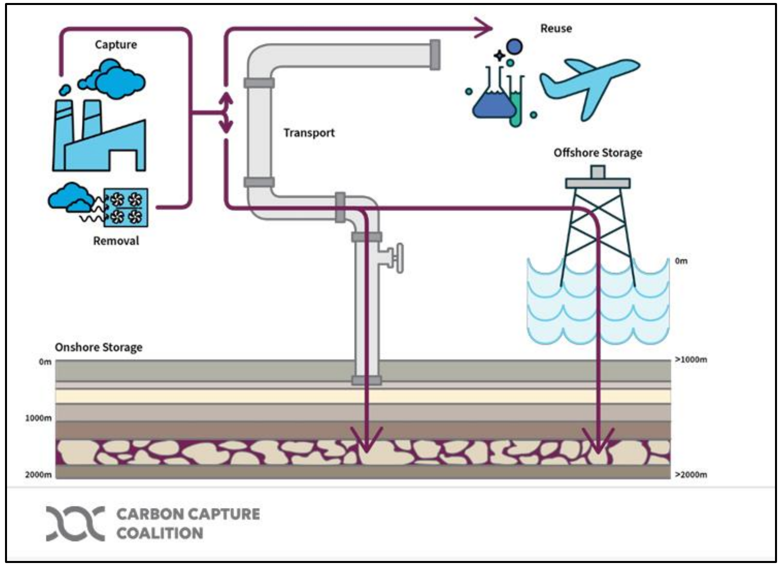
***it's not that simple…**

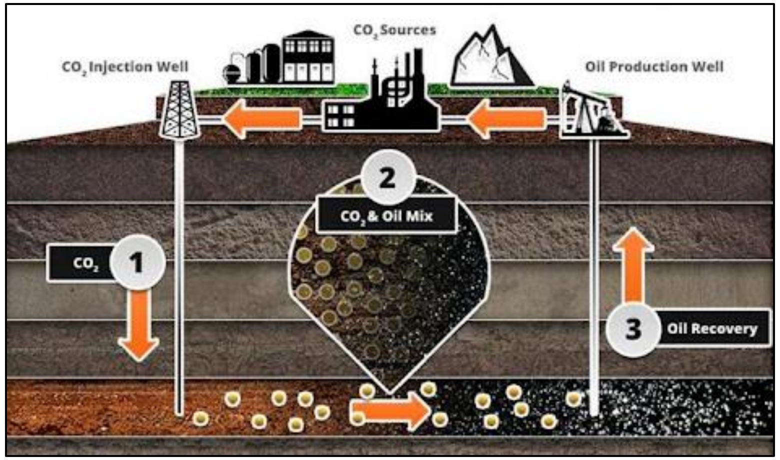
- Direct charges/fee-for-service
- Dedicated Property Tax
- Mandatory Programs

- Free market vs real-world economics
- Public goods, market failure, stability, regulation
- Corn, gasoline, soybeans, cotton, cattle etc.

Definitions

- 45 Q:
  - The foundational policy mechanism for the build-out of domestic (US) carbon management industry.
  - Provides a per metric ton credit for the capture and storage or reuse of CO_2 either from industrial sources or directly from the atmosphere
- EOR:
  - Method used for oil recovery from existing fields after conventional methods have been exhausted.
  - CO_2 injection is a common method (CO_2 mixes with oil and increases field pressure, pushing oil to production wells)
- Primacy
  - EPA delegates primary enforcement authority for specific well types
  - States must prove their regulations are as stringent as federal ones, have effective enforcement and sufficient resources to administer the program





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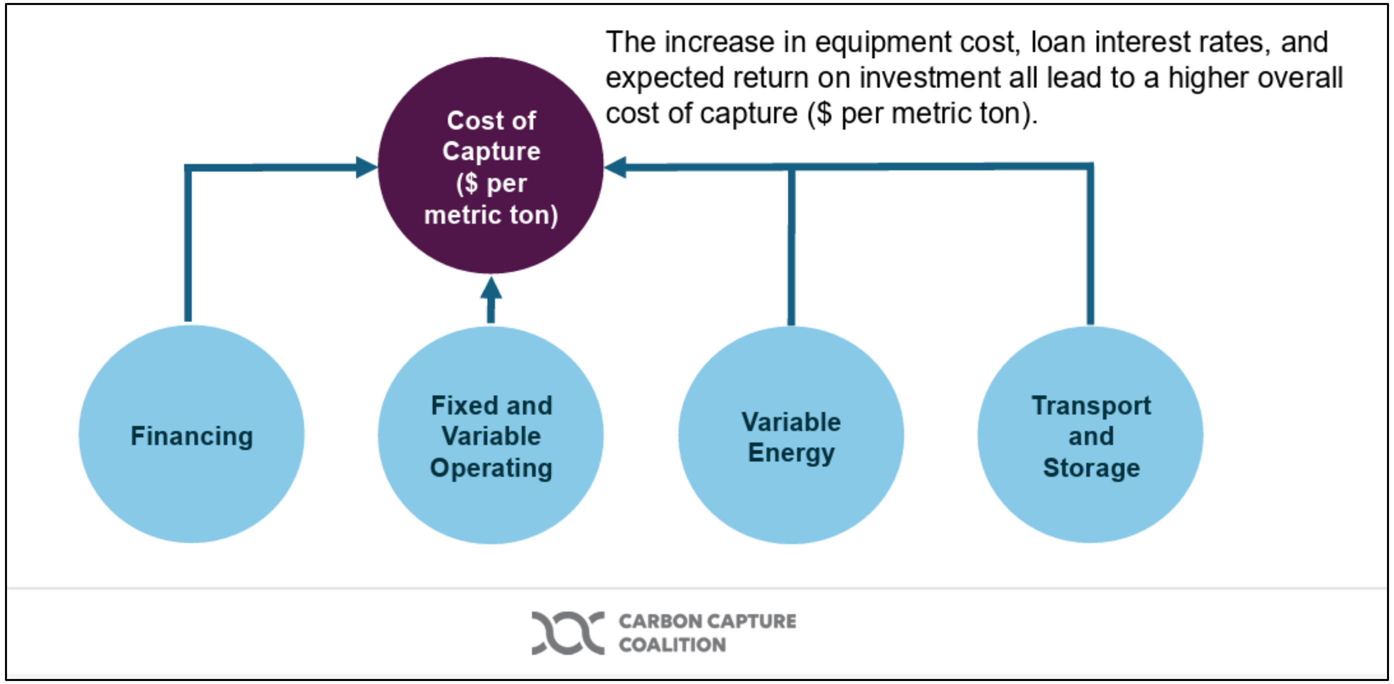
45Q Evolution

- 2008 45Q Established
  - $20 for storage
  - $10 for EOR
- 2018 FUTURE Act: Raises value of 45Q
  - $50 for storage
  - $34 for EOR
- 2022 IRA raises value
  - $85 for storage
  - $60 for EOR
  - $180 for DAC
- 2025 OBBB parity measures
  - $85 for storage
  - $85 for EOR

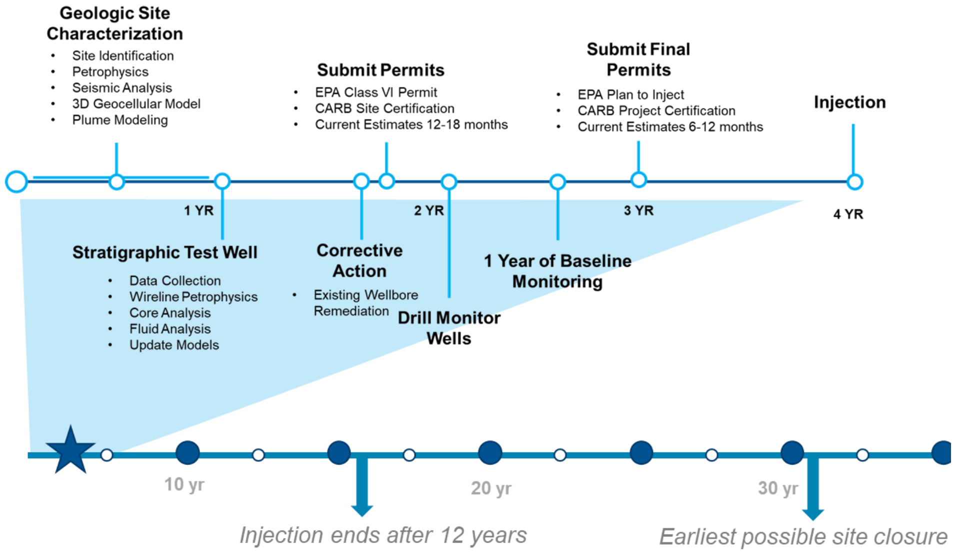
Real Value vs. Inflation

- Erosion in real value ($ per ton in 2022 vs. $ per ton in 2025)
- OBBB: credit begins adjusting for inflation in 2027

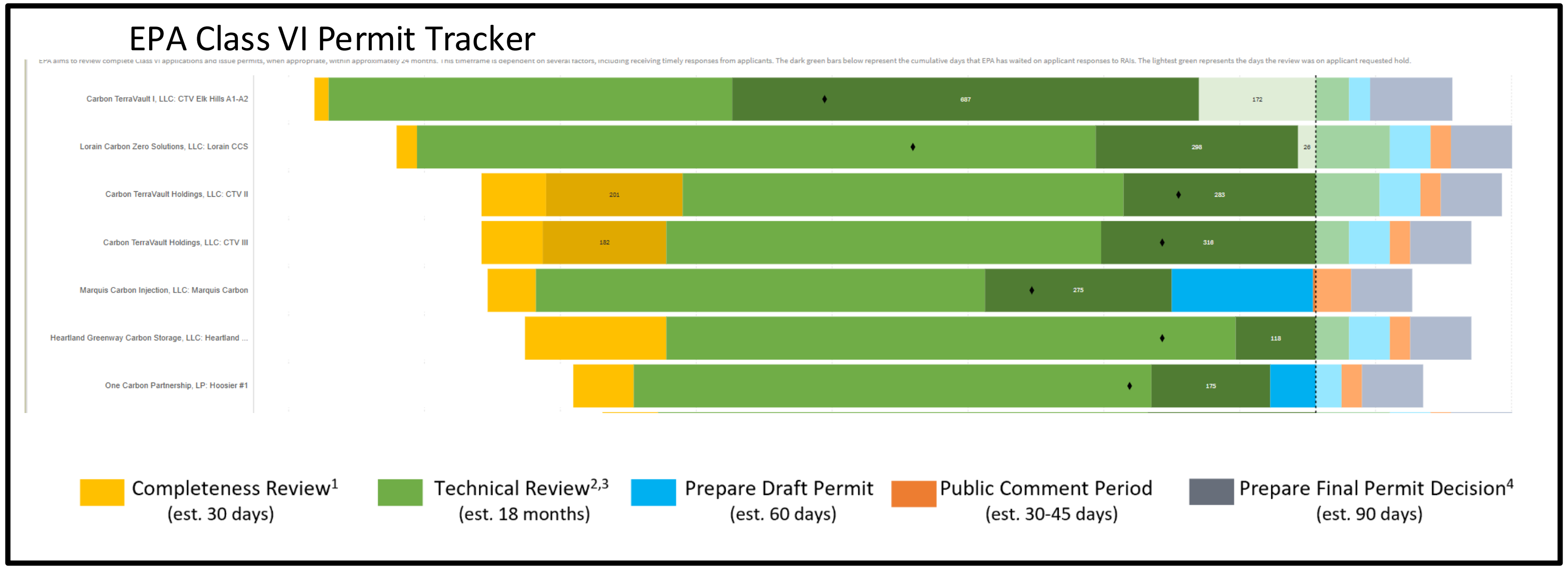


- Some advocacy groups are working towards industry specific credit adjustments

Why Permitting is Important



- Applying for and receiving a permit through the EPA can take several years
- Approval timelines have significant variability
- The process is iterative, with several review phases, requests for additional information, and a public comment period
- The EPA permit tracker was developed to help orient operators and the public on permit status



So, What's Taking So Long?

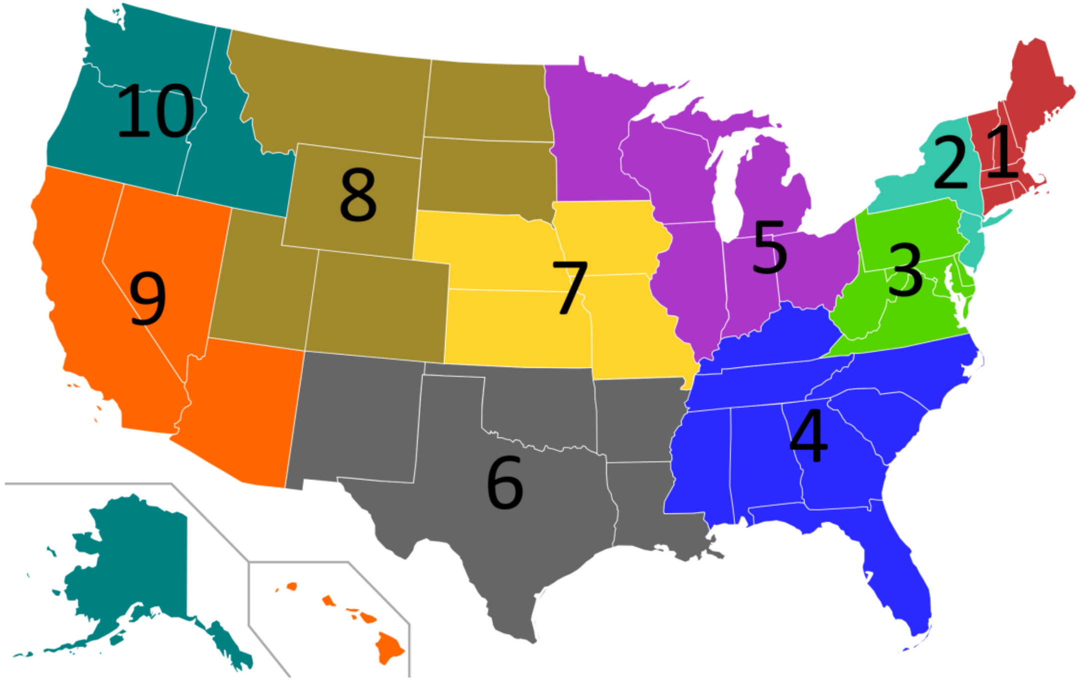
Class VI Summary Metrics					
Projects Currently Under Review	Well Applications Currently Under Review	Final Permit Decisions Issued	% of Applications Received in Last 12 Months	Applications for which EPA is Waiting for Applicant Response	Applications Currently On Applicant Requested Hold
67	239	11	44%	108	6

Metrics for Well Applications Currently Under Review (by Review Phase)				
Well Applications in Completeness Review Phase	Well Applications in Technical Review Phase	Well Applications in Prepare Draft Permit Phase	Well Applications in Public Comment Period Phase	Well Applications in Prepare Final Permit Decision Phase
58	169	1	8	3

- There is a huge volume of recently submitted permits
- Permits often include 1-2 years of technical work prepared by a team of SME's
- EPA regions are responsible for multiple states, spanning diverse geologic settings
- Regional distribution is uneven

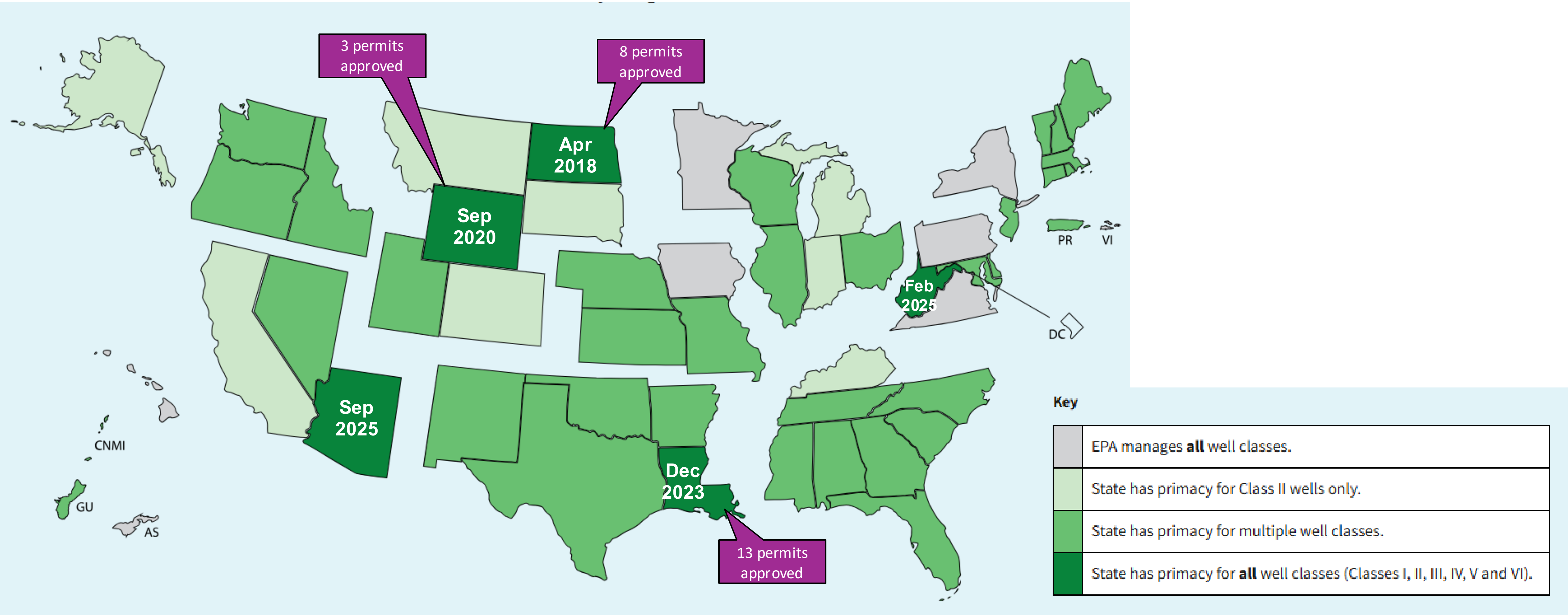
EPA Region	Permits Currently Under Review
4	51
5	46
6	81
7	4
8	2
9	55

United States
EPA Regions



Class VI Primacy and Permitting Status

- States with Class VI Primacy: ND, WY, WY, WV
- EPA has issued ~11 final Class VI permits
- Permit timelines continue to be a major variable



State-level Levers and other Incentives

- State Action
  - California: LCFS- Low Carbon Fuel Standard
  - Wyoming: Exploring EOR-favoring tax treatment and severance exemptions
  - North Dakota: pore space aggregation litigation ongoing

- Stacking Credits
  - Inclusion of LCFS can materially change project economics
  - Free Market/Voluntary Carbon Market Credits
    - Additionality considerations
  - Low carbon product markets

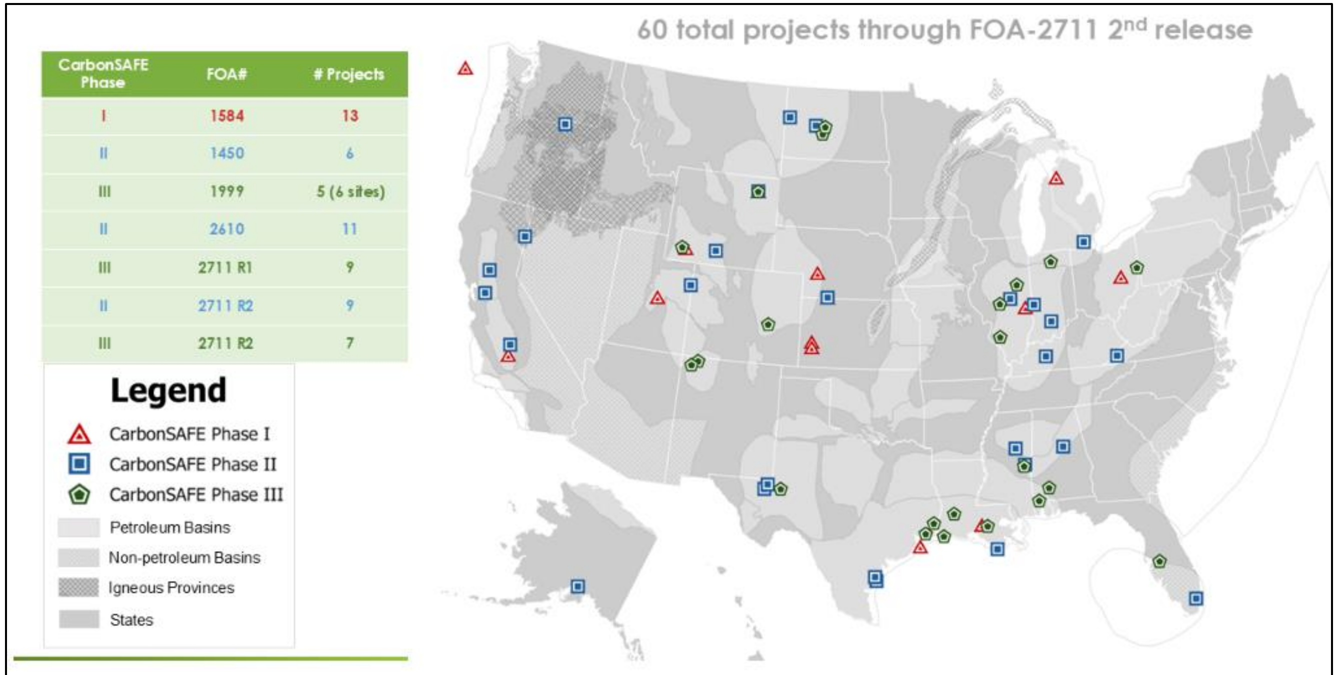
CarbonSAFE: derisking storage complexes

- CarbonSAFE: DOE program to fund CCS projects with federal dollars
  - Phase I: Integrated CCS Pre-Feasibility
  - Phase II: Storage Complex Feasibility
  - Phase III: Site Characterization and Permitting
  - Phase IV: Injection Site Construction
- Financial support improves operators' ability to gather data
- Encouraged industry-academic partnerships
- Included a focus on benefiting local communities

Table 1: Relevant information on the CarbonSAFE initiative funded under the Bipartisan Infrastructure Law (BIL)

Category	Details
Investment from BIL	$2.5 billion
Timeframe for Appropriations	FY 2022–FY 2026
Availability	Until expended
Funding Opportunity Announcement	DE-FOA-0002711 (FOA-2711)
Awarded Funds	~$595 million
Awarded Projects	- 8 Phase II projects - 15 Phase III projects
Ongoing Award Negotiations	~$560 million - 12 Phase II projects - 10 Phase III projects - 1 Phase III.5 project - 1 Phase IV project

Source: Carbon Capture Coalition, January 6, 2025



- Launched in 2016 by DOE
- Bipartisan Infrastructure Bill dedicated >$12 B for CCUS technologies
- IRA continued BIL funding for CCUS projects
- DOE cancelled $3.7B in carbon capture and decarbonization awards in 2025+

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What OBBB means for projects

- Parity for EOR and CCS = EOR economics improve
- Transferability preserved = maintains wide financing options
- No inflation-related increase = lower margins on project economics

Is more EOR a good thing?

Yes!

- Stronger economics o
  means CO_2 storage w
- More EOR operations
  infrastructure
- Could accelerate capt
  development with mor
- Improves operators' a
  maximum volume of c
  already developed fields

No!

ore oil and gas

do not require the
hnical review process

ect CO_2 to improve
ntivize this with

IEA's September 2025 Report

Recommendations include: "catalogue and support technology development that aligns resource extraction with global and national emissions reduction objectives. This includes the need for the oil and gas industry to reduce its scope 1 and 2 emissions. **A key example is CO2-based enhanced oil recovery (EOR), which can increase production while sequestering more carbon dioxide than is released from the production and combustion of the extracted oil."**

2025-2028 Outlook

What to keep an eye on:

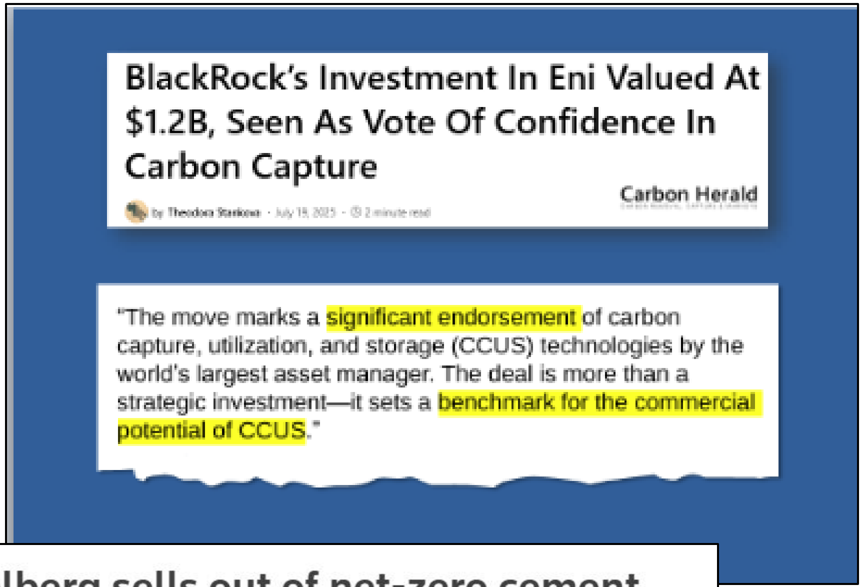
- Primacy Expansion
- Credit Stacking durability
- Demand increase from AI/data centers

How 2025 has changed the industry

- US Federal Level Policy
  - E.O to expedite permitting : major cuts to agencies that grant permits
  - ‘Climate change is not human induced’ : continued support of CCUS
  - EPA to eliminate emissions reporting (Sept. 2025)
    - Generates significant uncertainty in how 45Q credits will be awarded

Takeaways

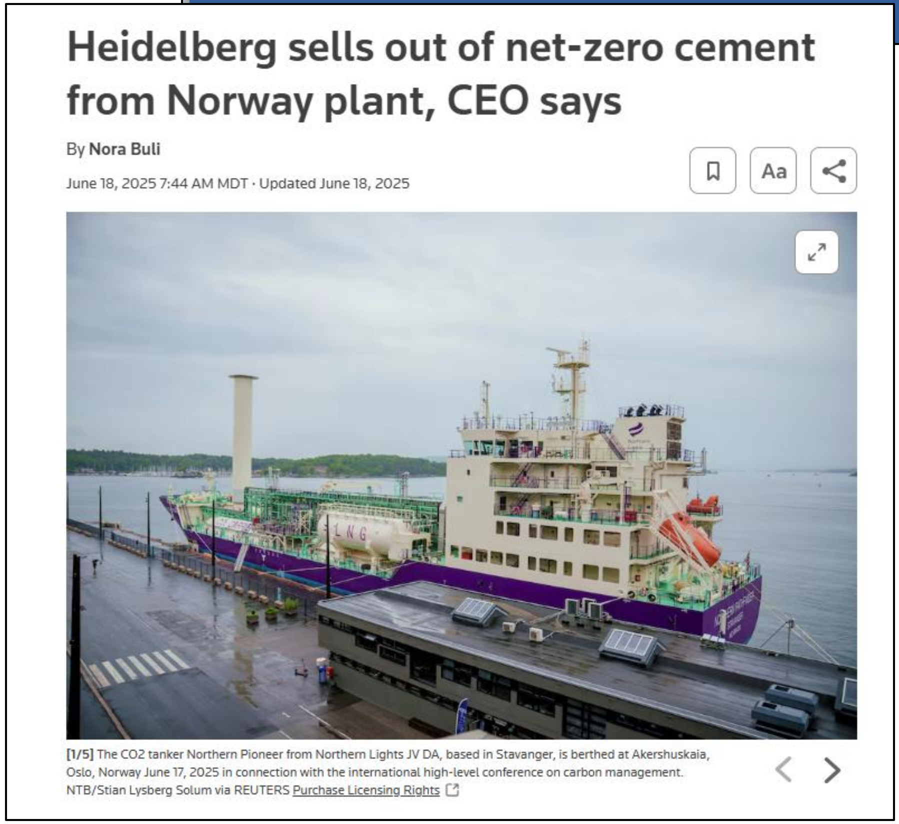
- 45Q parity is a big shift, favoring EOR
- Value erosion from inflation (will remain until 2027 adjustments)
- State policies can swing project siting timelines significantly
- Uncertainty is high as long as we are dependent on federal subsidies
- Market signals are strong even with the early 2025 turmoil
  - There are now 41 commercial-scale CCUS facilities in operation globally
  - >350 projects actively in development
  - >80 companies offer CCUS technologies
  - Industrial scale projects are becoming more prevalent



BlackRock's Investment In Eni Valued At $1.2B, Seen As Vote Of Confidence In Carbon Capture

Carbon Herald

"The move marks a significant endorsement of carbon capture, utilization, and storage (CCUS) technologies by the world's largest asset manager. The deal is more than a strategic investment—it sets a benchmark for the commercial potential of CCUS."



Heidelberg sells out of net-zero cement from Norway plant, CEO says

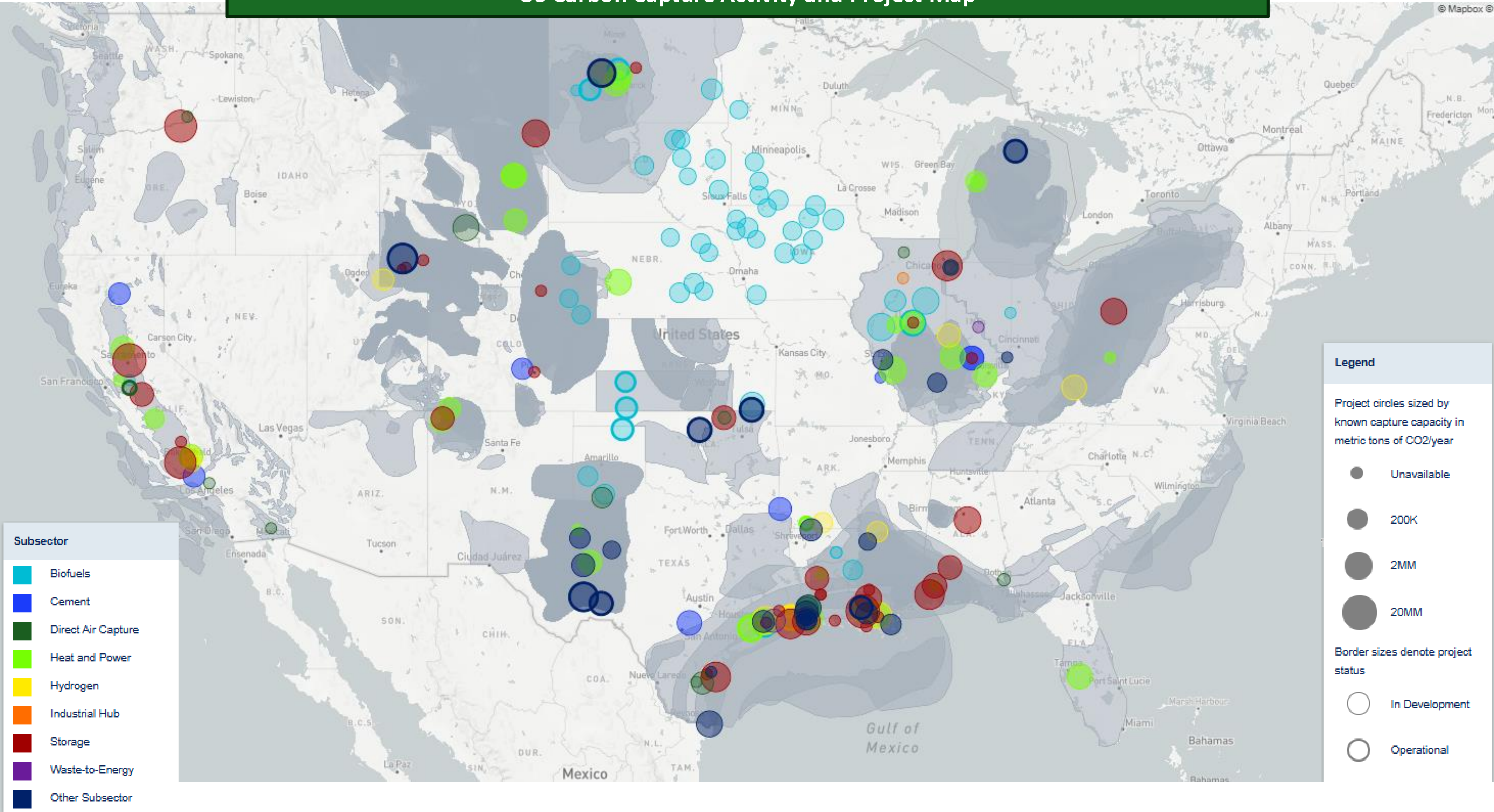
By Nora Buli

June 18, 2025 7:44 AM MDT · Updated June 18, 2025

[1/5] The CO2 tanker Northern Pioneer from Northern Lights JV DA, based in Stavanger, is berthed at Akershuskaia, Oslo, Norway June 17, 2025 in connection with the international high-level conference on carbon management. NTB/Stian Lysberg Solum via REUTERS Purchase Licensing Rights

Questions?

US Carbon Capture Activity and Project Map



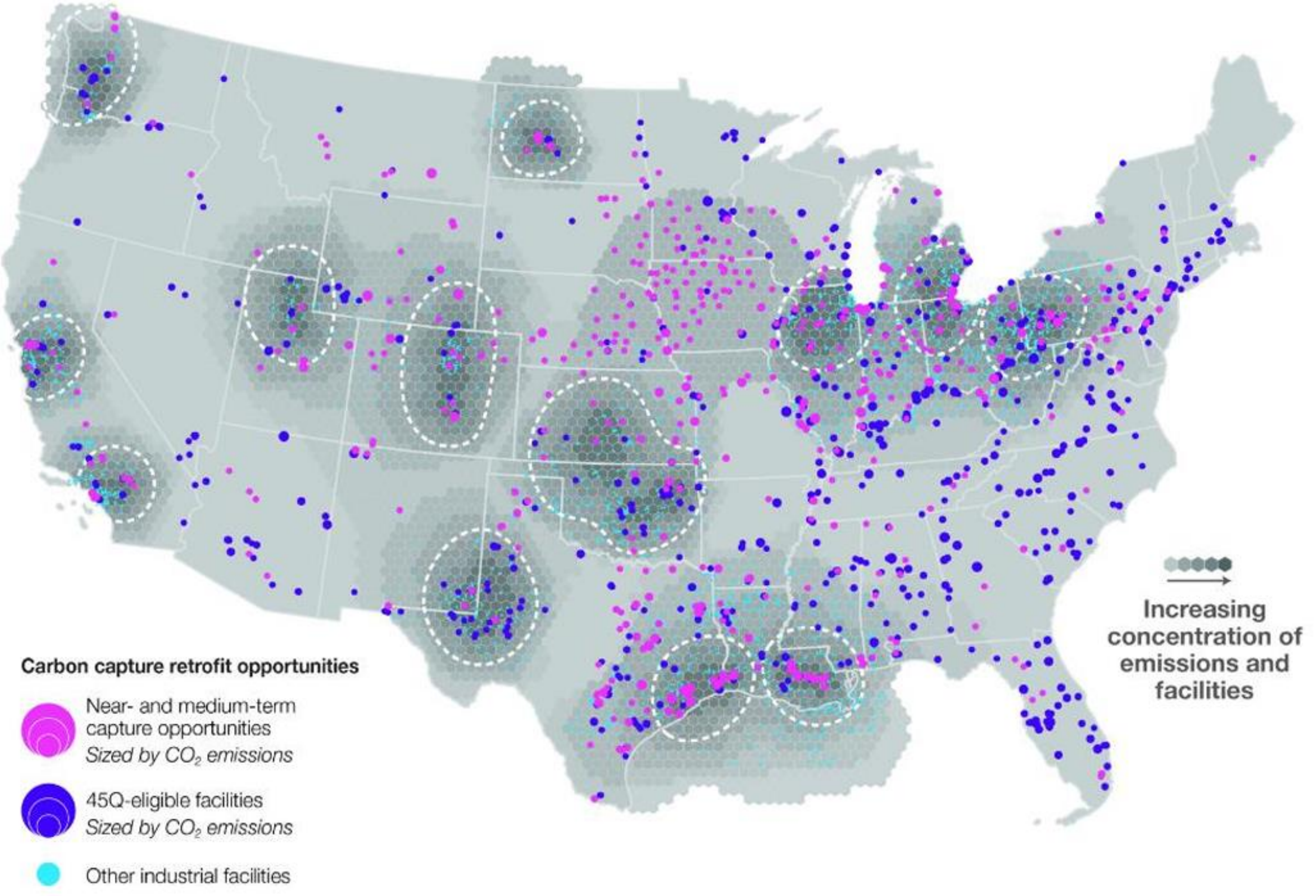
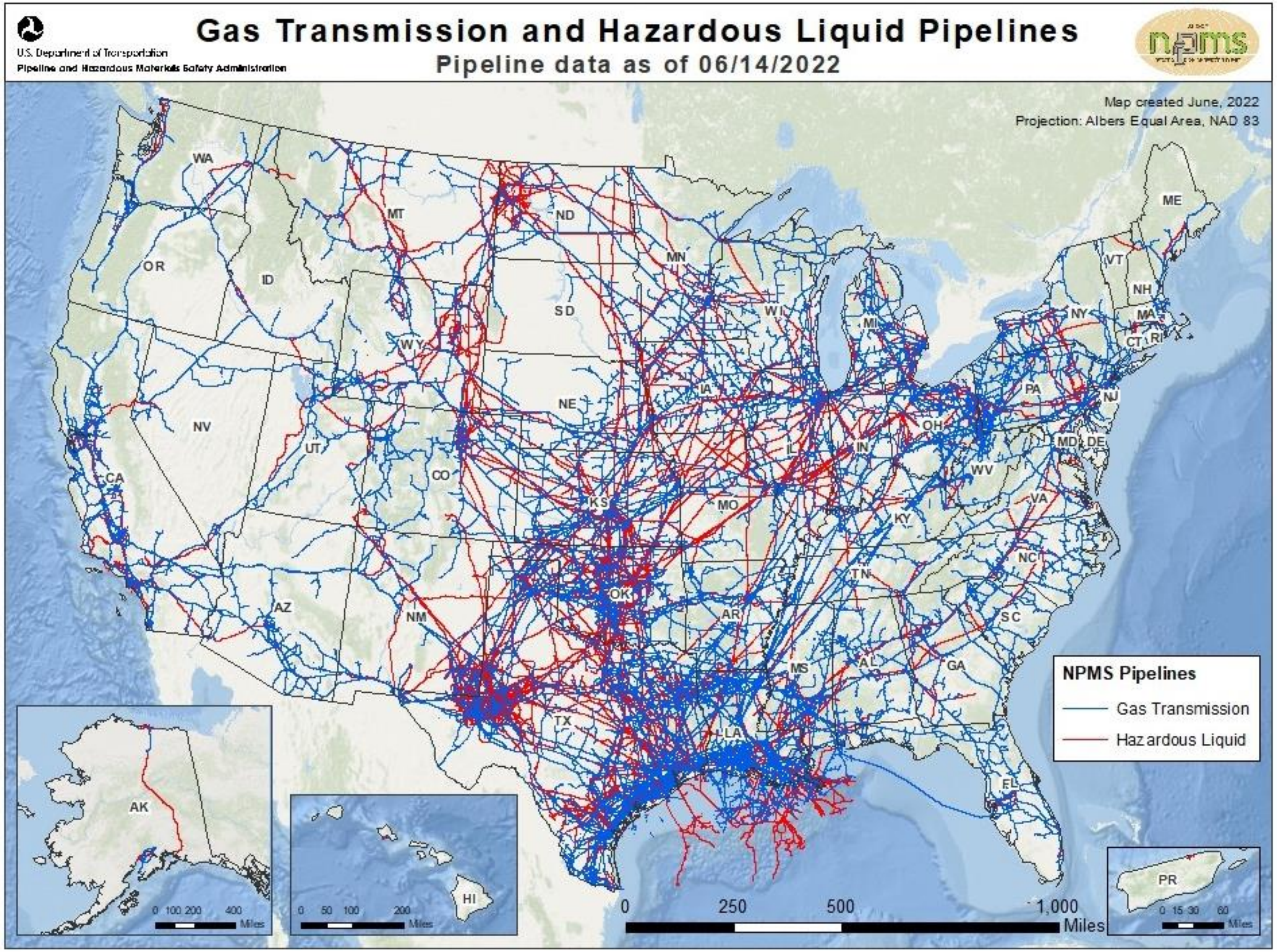


Figure authored by GPI based on Abramson, McFarlane, and Brown, *Transport Infrastructure for Carbon Capture and Storage*; EPA GHGRP 2019 data (as of August 7, 2021).

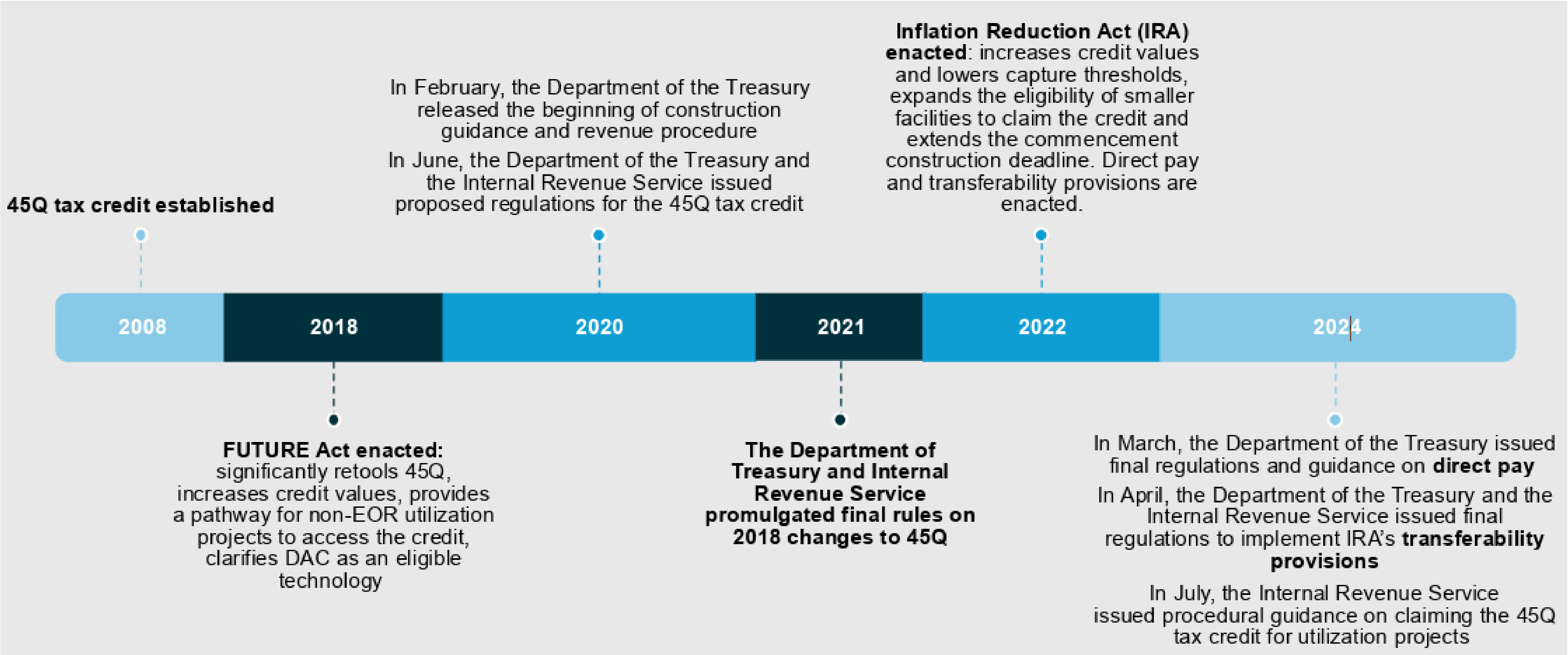
More on Pipelines…



The CO_2 pipeline network in the US exceeds 5,000 miles

- ~260,000 miles of hazardous liquid pipelines
- ~3,000,000 miles natural gas pipelines

Estimates on the need to expand range from 4x to 18x the existing mileage



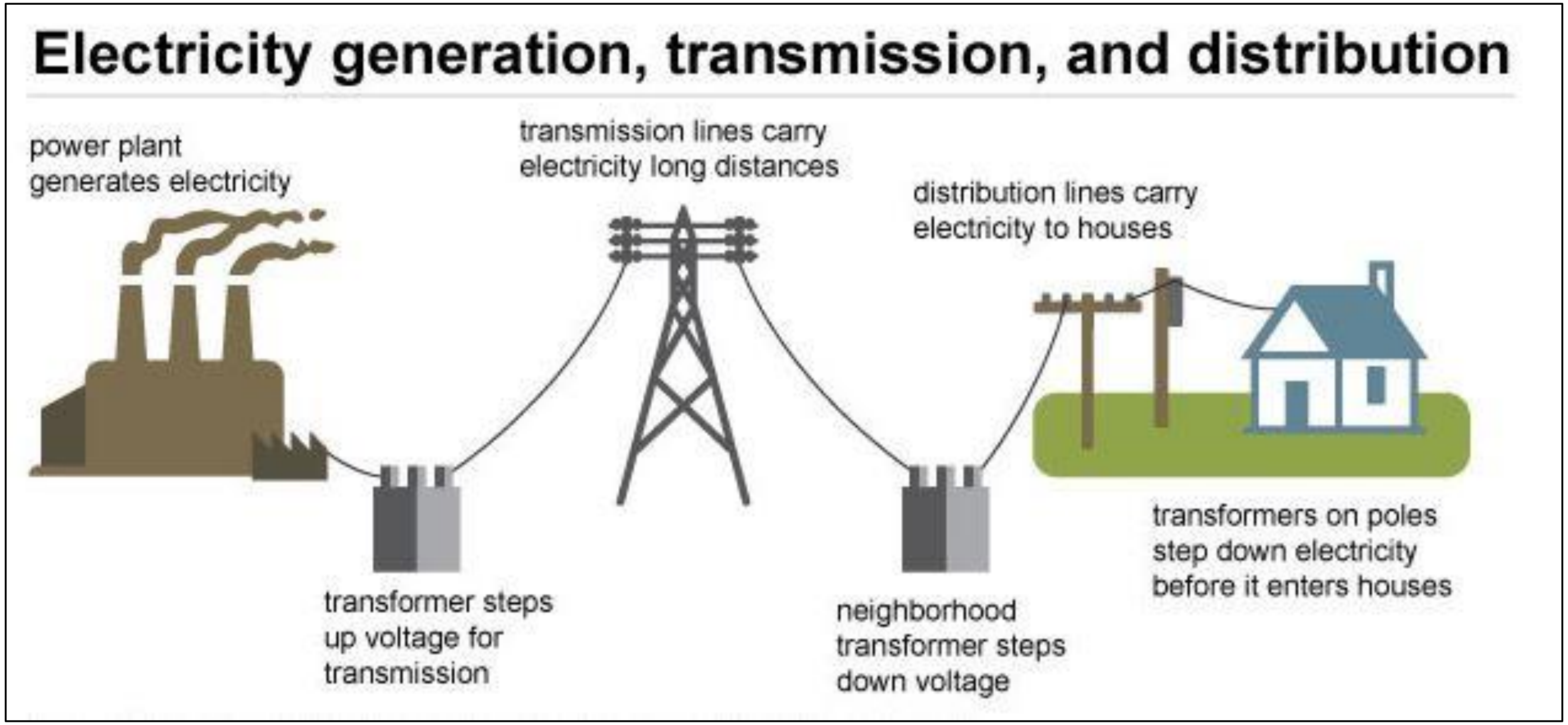
45Q tax credit established
In February, the Department of the Treasury released the beginning of construction guidance and revenue procedure
In June, the Department of the Treasury and the Internal Revenue Service issued proposed regulations for the 45Q tax credit
Inflation Reduction Act (IRA) enacted: increases credit values and lowers capture thresholds, expands the eligibility of smaller facilities to claim the credit and extends the commencement construction deadline. Direct pay and transferability provisions are enacted.
2008
2018
2020
2021
2022
2024
FUTURE Act enacted: significantly retools 45Q, increases credit values, provides a pathway for non-EOR utilization projects to access the credit, clarifies DAC as an eligible technology
The Department of Treasury and Internal Revenue Service promulgated final rules on 2018 changes to 45Q
In March, the Department of the Treasury issued final regulations and guidance on direct pay
In April, the Department of the Treasury and the Internal Revenue Service issued final regulations to implement IRA's transferability provisions
In July, the Internal Revenue Service issued procedural guidance on claiming the 45Q tax credit for utilization projects

Category	Class II — Oil & Gas-Related Injection	Class VI — CO_2 Geologic Sequestration
Purpose / Scope	Injection associated with oil & gas (produced-water disposal, EOR/tertiary recovery, hydrocarbon storage). Not intended for permanent CO_2 sequestration.	Injection of CO_2 for long-term geologic sequestration beneath the lowermost USDW; purpose-built for permanent storage.
Core Regulations	SDWA UIC (40 CFR Parts 144–147); Class II-specific requirements.	SDWA UIC (40 CFR Parts 144–147) with GS-specific rules (40 CFR Part 146 Subpart H).
Area of Review (AoR)	AoR delineation per UIC; methods tailored to oil & gas operations.	Modeling-based AoR predicting CO_2 plume and pressure front; periodic re-evaluation and corrective action.
Monitoring / MRV	Mechanical integrity; injection pressure/volume; fluids monitoring as applicable.	Comprehensive GS monitoring (pressure, geochemistry, plume tracking), Class VI recordkeeping; aligns with GHGRP Subpart RR.
Post-Injection Site Care (PISC)	No GS-specific default period; closure per Class II requirements.	Default 50-year PISC (adjustable by Director) with required PISC & closure plan.
Financial Responsibility	Financial assurance consistent with oil & gas injection operations.	Expanded financial responsibility covering corrective action, injection, PISC, emergency/response.
Injection Formation / Depth	Oilfield formations for disposal or EOR, often within producing strata.	Qualified storage formations beneath the lowermost USDW with competent confining units (waivers only under strict criteria).
Administration / Primacy	Administered by EPA or primacy states; program must be at least as stringent as federal rules.	Same; Class VI primacy states/tribes administer GS permits if approved by EPA.
Typical Use Cases	Produced-water disposal; CO_2-EOR (creditable under some policies but remains Class II).	Dedicated CO_2 storage (saline formations; depleted reservoirs repurposed for GS) to meet policy/market sequestration requirements.
Timeline / Complexity (Practical)	Shorter lead times; less up-front GS-specific characterization and MRV.	Longer lead times due to site characterization, modeling, MRV plans, and PISC/financial responsibility.

Emission and Power Generation

- As of 2023 Natural Gas and Coal account for 60% of utility scale generation in the US
- Wind = 10%, Hydro 6%, Solar 4%

60% of total emissions

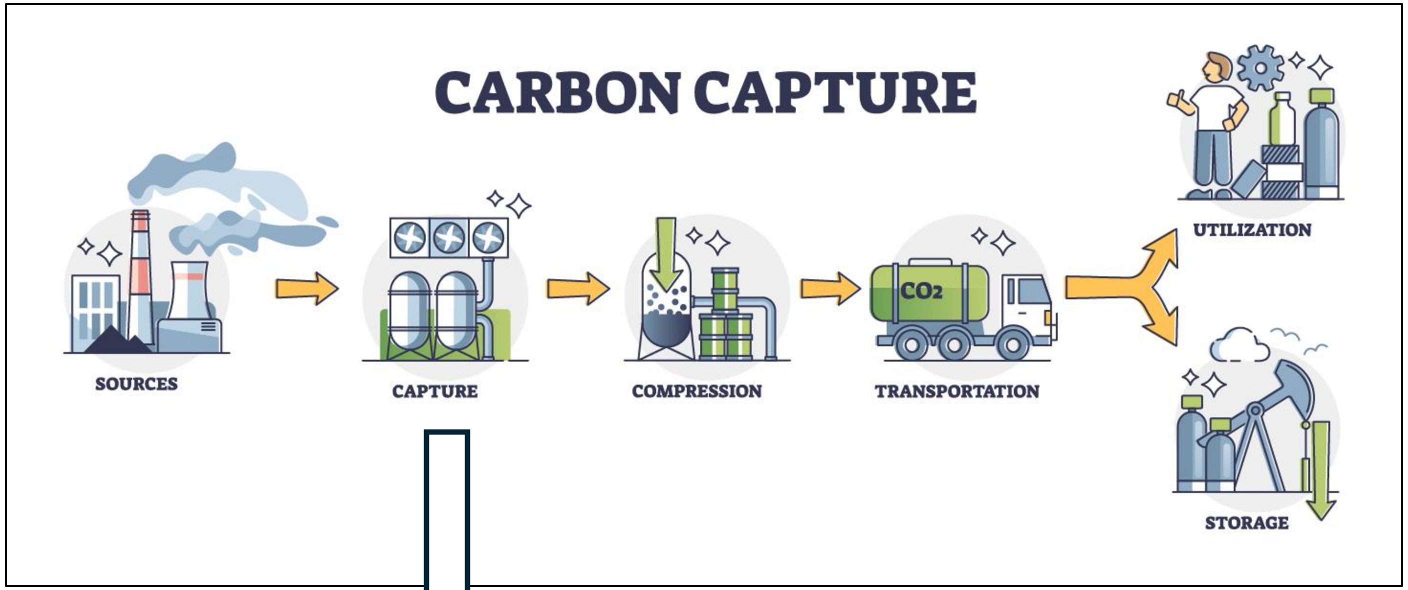


Energy and electricity are not synonymous

Carbon Capture and Storage: Technology Overview

- CO_2 emissions from industrial sources (like power plants, cement manufacturers, ethanol plants) can be captured on-site

- Other polluting gases and particulate matter may be captured as part of the process, improving local air quality



- **Post-Combustion: capture CO_2 from emissions produced from industrial processes or burning fossil fuels**
- Pre-Combustion: fossil fuels are treated before being burned, CO_2 is capture and hydrogen is burned
- Oxyfuel Combustion: burning fossil fuels in pure oxygen (rather than air) creating a pure CO_2 and water vapor stream

Mature technology, most widely deployed

Commercially available but uncommon

Demonstration phase, few pilot projects

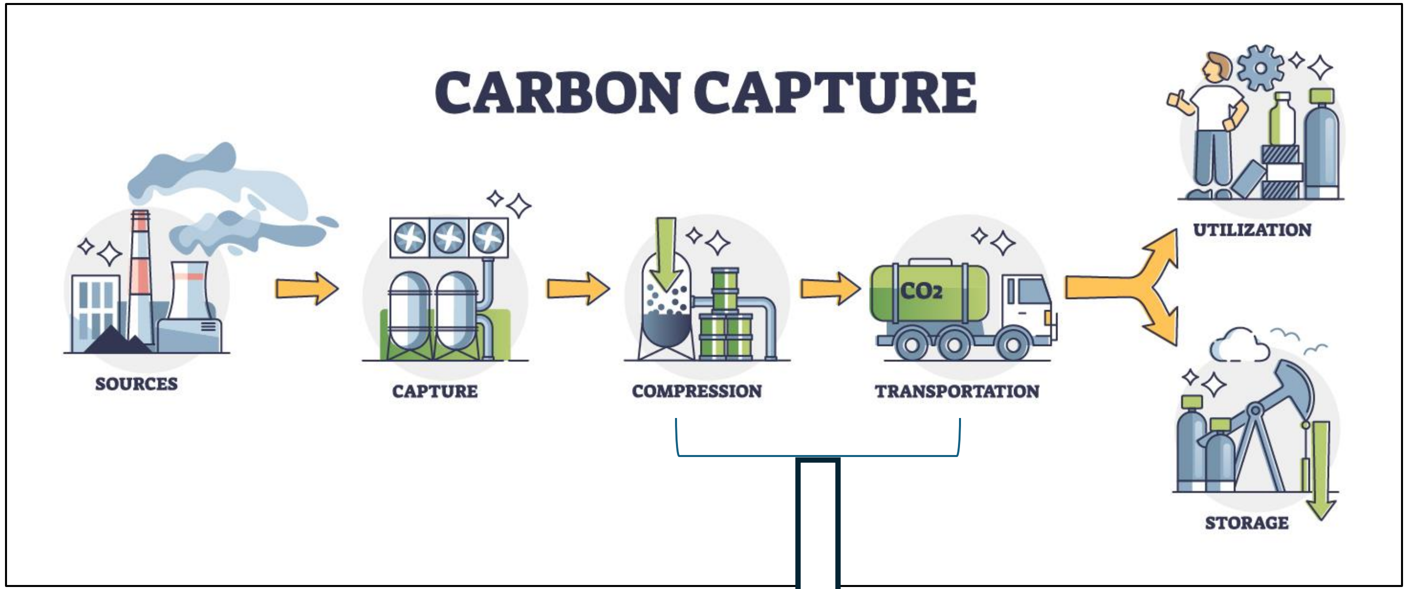
Capture Tech

How can we efficiently isolate CO_2 molecules from either ambient air or emissions streams

- The emission mix (of gases and particulate matter) will dictate what type of capture is most appropriate

Amine-Based Solvents	Membrane Separation	Cryogenic Separation	Calcium Looping	Solid Sorbents /Metal Organic Frameworks (MOFs)
Liquid solvents chemically absorb CO_2. Heat is added to release CO_2	Membranes allow CO_2 to pass through, blocking other gases	Flue gases are cooled to condense CO_2 and capture it in liquid form	CaO reacts with CO_2 forming $CaCO_3$. This is heated to release CO_2, producing calcium oxide for reuse	Solid materials adsorb CO_2, heat or pressure is used to release it.
Strengths: High capture rate Easily added to existing infrastructure	**Strengths**: Simple operation, low maintenance	**Strengths**: High purity of CO_2 captured, no chemical solvents	**Strengths**: Low energy consumption, suitable for high CO_2 concentrations	**Strengths**: Lower energy requirements, high CO_2 selectivity
Challenges: Energy intensive, degradation of solvent	**Challenges**: Lower efficiency and high cost for large applications requires high CO_2 conc.	**Challenges**: Very energy intensive and high cost	**Challenges**: High temperatures required, material degradation over time	**Challenges**: High cost and material degradation over time

Compression and Transportation



1

- Compression and dehydration of CO_2 is performed in preparation for transportation and storage
- CO_2 is compressed to ~1100 psi, creating supercritical CO_2

2

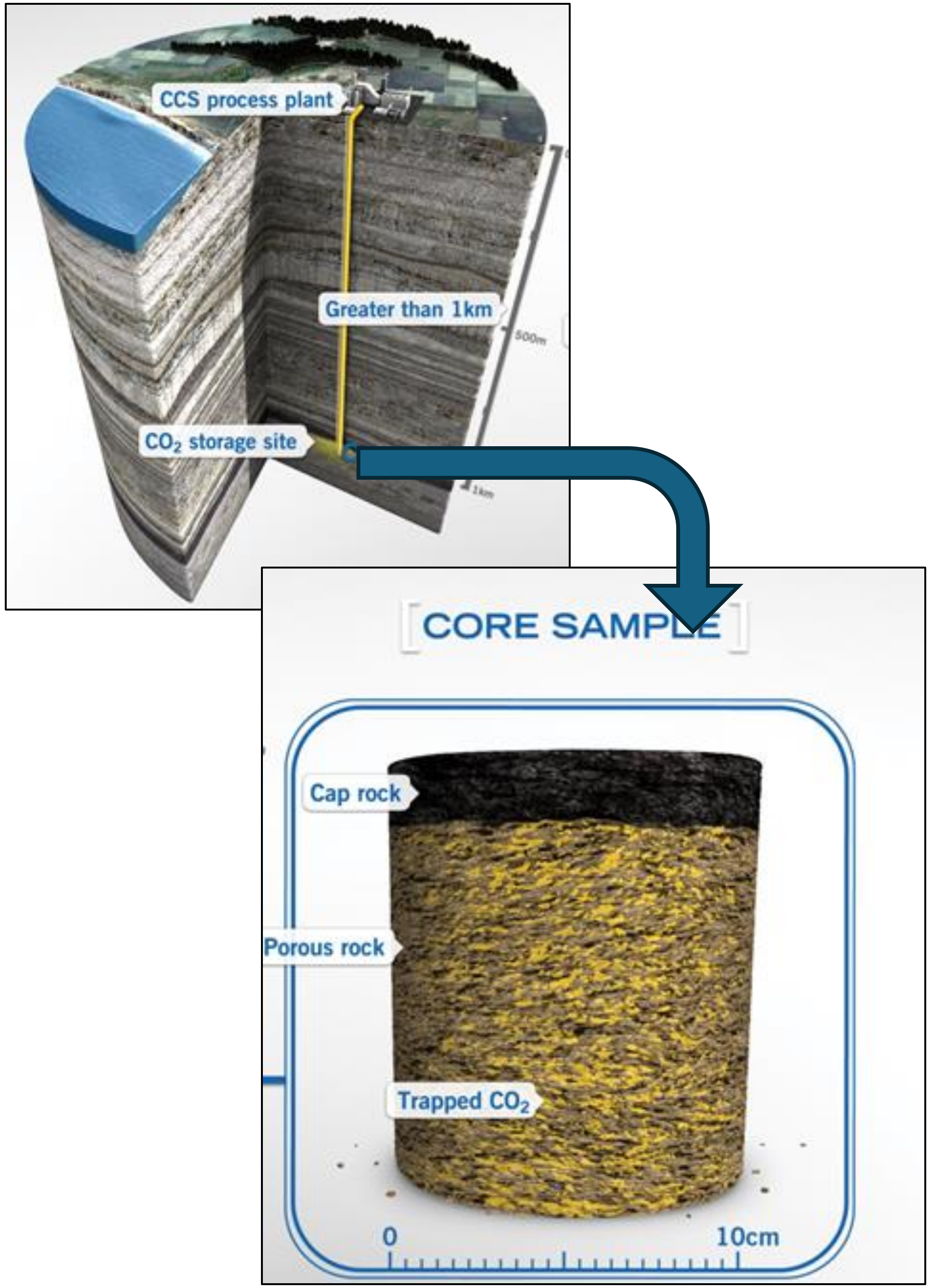
- Purified and compressed CO_2 is transported to the storage site by pipelines or road/rail carriers
- Pipeline materials must be corrosion resistant
- CO_2 pipelines are regulated by PHMSA

Geologic Storage

- At the storage site, CO_2 is injected underground through deep well, (typically over a mil deep)

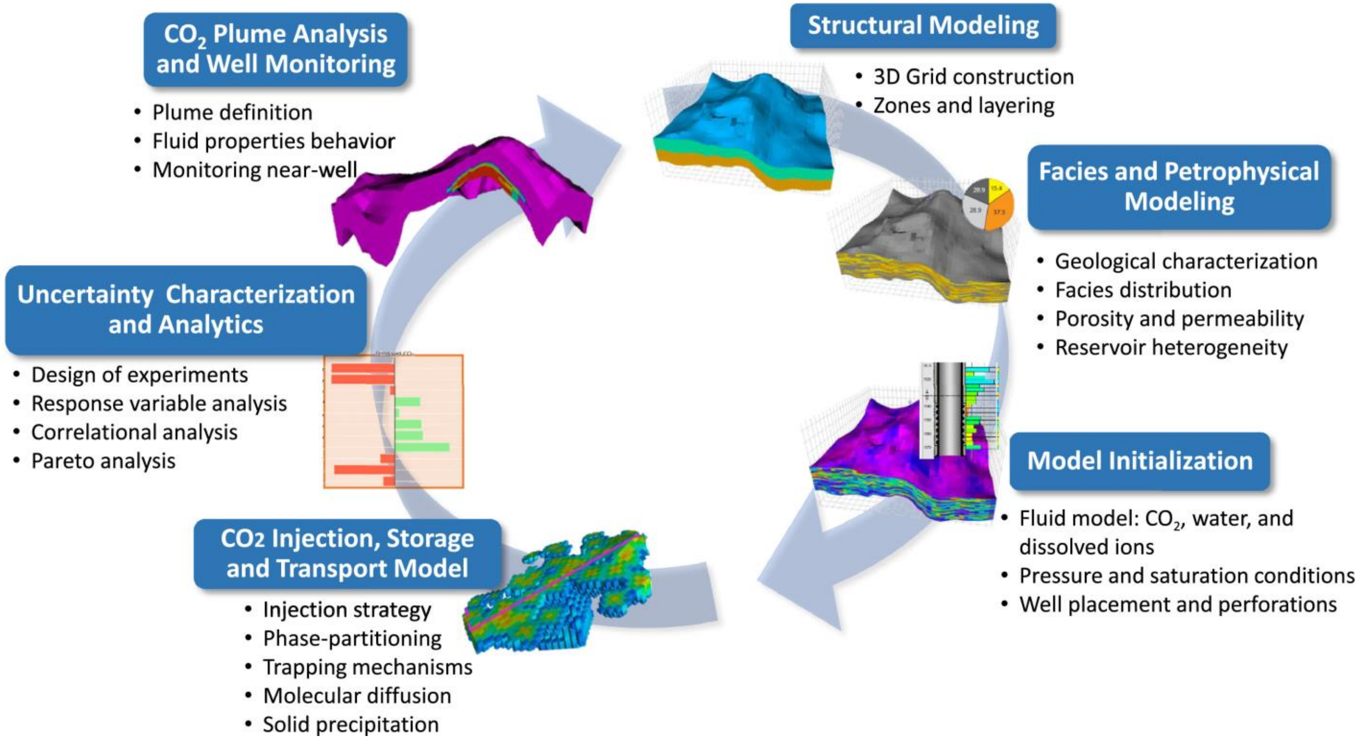
Regulations

- The EPA currently issues permits for CO_2 injection, witl stringent guidelines to ensure secure and safe storage



source: Global CCS Institute

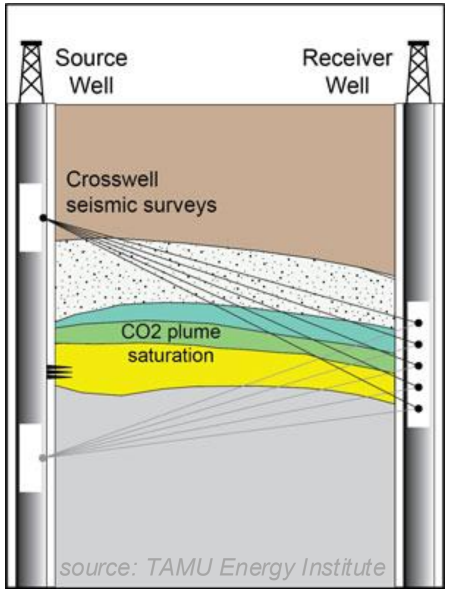
Characterizing the subsurface

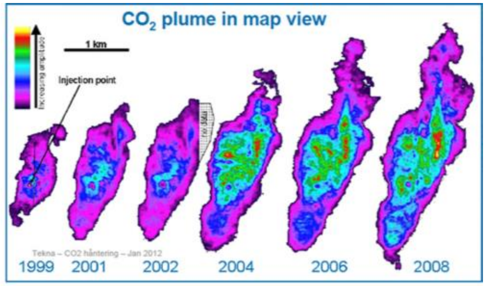


from Zapata et al 2022

- Technologies to assess the subsurface are well developed but constantly evolving and advancing
- Monitoring technologies for deep and shallow subsurface monitoring are unique to CCS

Deep Subsurface Monitoring





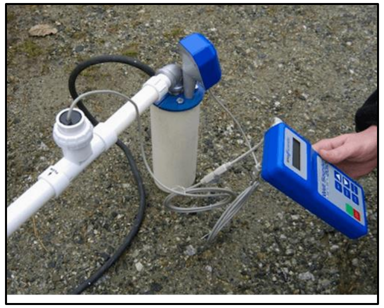
Seismic monitoring through time shows the plume evolution

Permanent downhole monitoring systems can measure pressure and temperature continuously

Shallow Monitoring

Atmospheric Monitoring

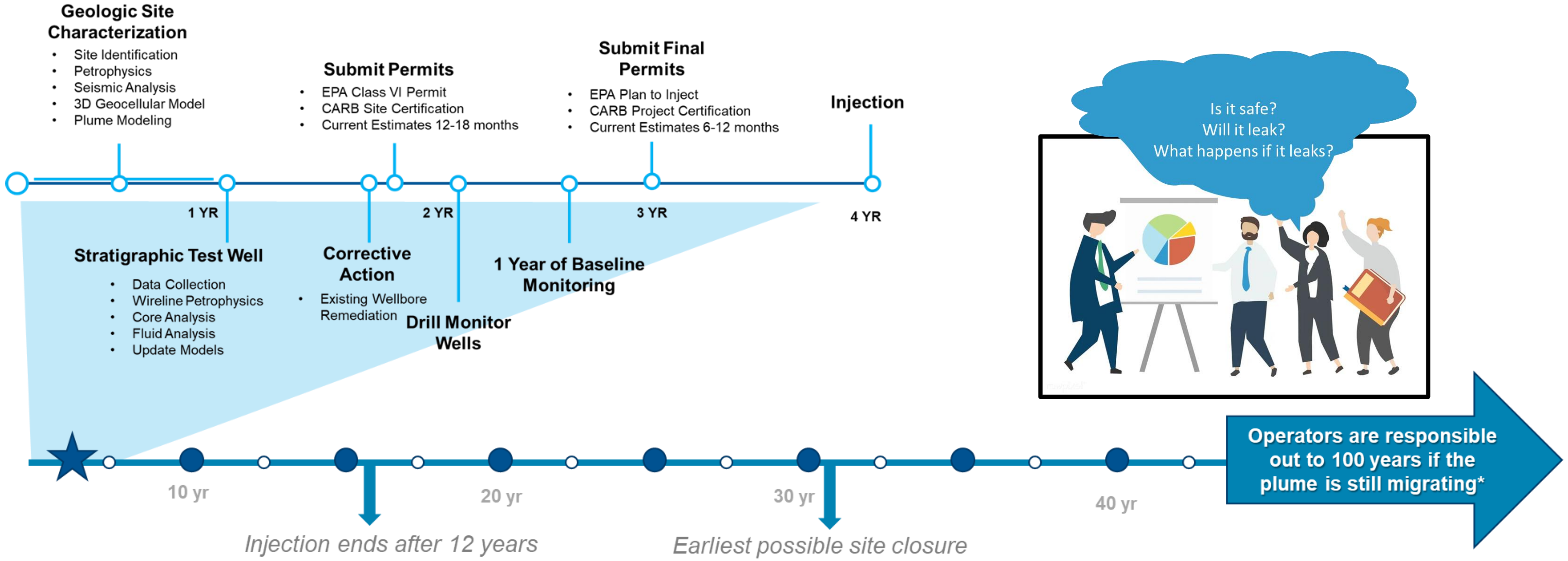
Soil gas monitoring



Shallow aquifer monitoring

CCS Project Timeline

- These timelines are unique to CCS projects compared to other industrial endeavors
- **This underlines the importance of well-planned, well-funded, and effective community engagement**



*In the US site closure is permitted within 15 years after injection ends, if the plume stability is verified