The Business Case for CCUS

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

2012
Interned with Anadarko Petroleum in Houston

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

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

2019
Join OXY Low Carbon Ventures Team

2021
Start PhD program at Colorado School of Mines

2022
Start Position as contract Geochemist at Carbon America

2022
Start as graduate intern at NREL on carbon projects

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

2010
Began graduate program at Texas A&M University

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

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

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

2019
OXY Acquires Anadarko

2020
Apply for voluntary severance from OXY

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

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Presentation Outline

- Intro and Definitions
- Why is CCUS attractive?
- Case Studies
- The changing landscape
- CCUS in Context
- Takeaways

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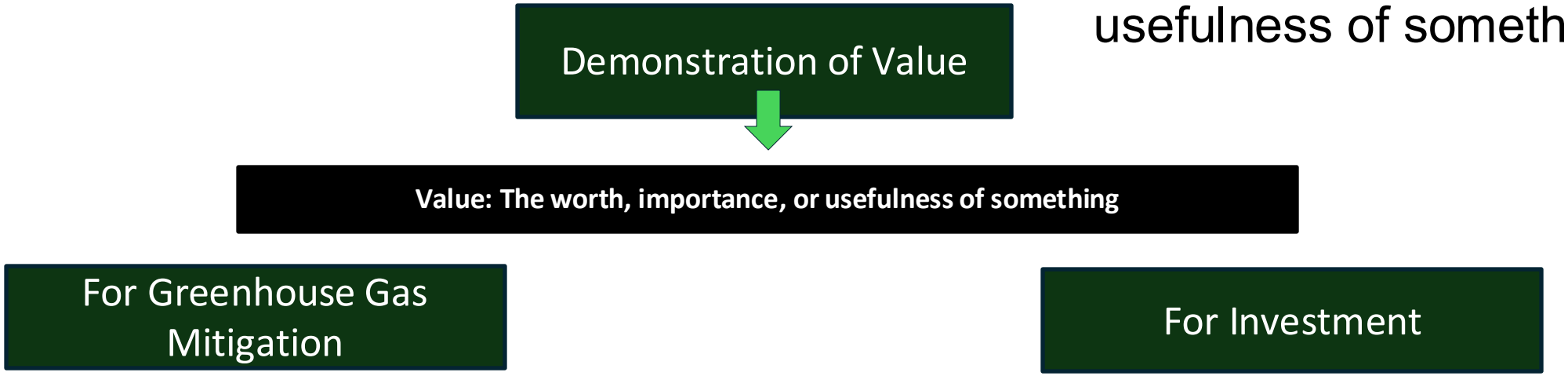
‘The Business Case’ = The Value Proposition

- What do we mean by business case?
- Value
  - The worth, importance, or usefulness of something



- Stored CO_2 = tonnes of CO_2 captured or removed and stored in subsurface formations
- Process emissions (generated as part of operational measures, powering facilities, transportation of CO_2, etc.)
- Upstream/Fugitive (leakage, non-permanence)

Stored CO_2 – (Process Emissions+ Upstream) = Net CO_2

- Bankable revenue (Tax credits, LCFS compliance, Product premiums, VCM)
- Cost: CAPEX/OPEX for capture, transport, storage, and monitoring
- Risk: permitting schedule, pore space access, price/policy volatility,

(Incentives + Premiums) – (Full Lifecycle Cost) ± Risks = Investability

Why is CCUS Attractive?

…or why are we doing this?

For Climate Mitigation

- Most modeled scenarios require a large volumetric contribution from CCS to achieve net-zero goals
- Addresses hard-to-abate emissions (like cement where fuel switching doesn't cut CO_2)
- System reliability and technical practicality

For Investment

- Policy-backed revenue
  - Europe: EU ETS price signal plus public co-funding and merchant transport and storage models
  - UK Clusters: Contract-based support underpins capture and transport and storage revenue
  - US: 45Q tax credit, voluntary markets for engineered removals

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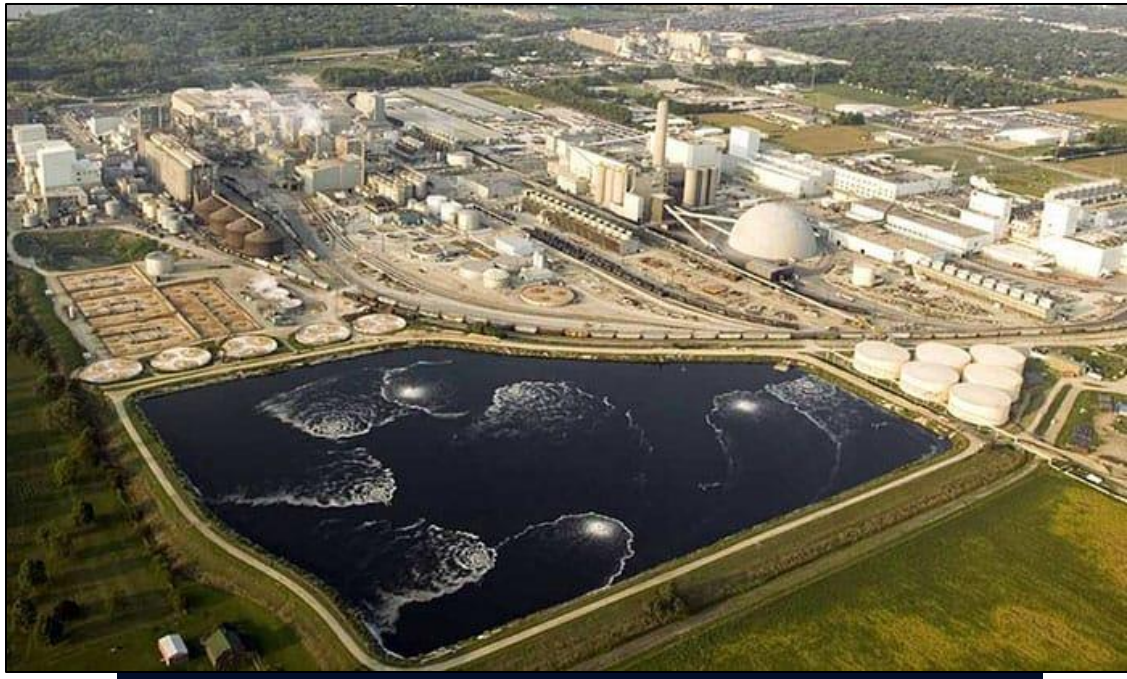
Case Study: ADM Decatur (ethanol + saline storage)

- Location: Decatur, Illinois, USA
- Operator: ADM with ISGS; DOE NETL supported
- Geologic setting: Mt. Simon Sandstone ~2130-2149m
- Distance source to injection: 1.9 km pipeline on site
- First Operation: IBDP Nov 2011; ICCS began 2017
- Status: Paused 2024; injections restarted Aug 29, 2025
- CO_2 stored: >4.5 Mt

- Key Economic Features
  - Biogenic CO2 eligible for 45Q
  - Proximity to storage
  - DOE cost share



ENERGYWIRE

Carbon storage site that leaked set to restart injections

By CARLOS ANCHONDO | 08/01/2025 06:44 AM EDT

Archer-Daniels-Midland's storage site in Decatur, Illinois, has been on pause since EPA found that brine and CO2 had likely migrated into unauthorized zones.

Investment:
(45Q for storage + DOE cost-share + Low transport cost) – (Capture/Compression + Class VI compliance/MRV + O&M) ± (Permit/operations risk, inflation) = **Investable where uptime is high and MRV is mature**

GHG mitigation:
Net mitigation = Biogenic CO_2 injected – (Electricity/steam for dehydration, compression, injection) – (Upstream energy CH_4/CO_2) – (Leakage risk, managed via Class VI MRV)

Case Study: Red Trail Ethanol (ND 1st Class VI permit)

- Location: Richardton, North Dakota, USA
- Operator: Red Trail Energy with UND EERC, acquired in Feb 2025 by Gevo Inc. (sustainable aviation fuel company) for $210 M
- Geologic setting: Broom Creek Formation ~5500-6500 feet
- Distance source to injection: Onsite
- First Operation: Injection began June 16, 2022
- Status: Operating
- CO_2 stored: 160,000 tCO_2/year (total capacity 1Mt)

- Key Economic Features
  - Biogenic CO2 eligible for 45Q
  - Proximity to storage
  - LCFS benefit potential/voluntary CORCs

Gevo Acquires North Dakota Assets After Red Trail Energy Shareholder Approval

by Vasil Velev · December 14, 2024 · 2 minute read

gevo®

RED TRAIL ENERGY

Investment:
(45Q for storage + Potential LCFS/CI uplift + Voluntary CORCs) – (Capture/Compression + Class VI compliance/MRV + O&M) ± (Policy/counterparty risk for LCFS/CORCs) =
Investable for onsite biogenic stream with minimal transport

GHG mitigation:
Net mitigation = Biogenic fermentation CO_2 injected – (Onsite compression/injection energy) – (Upstream electricity/fuel CH_4/CO_2) – (Leakage risk under Class VI MRV)

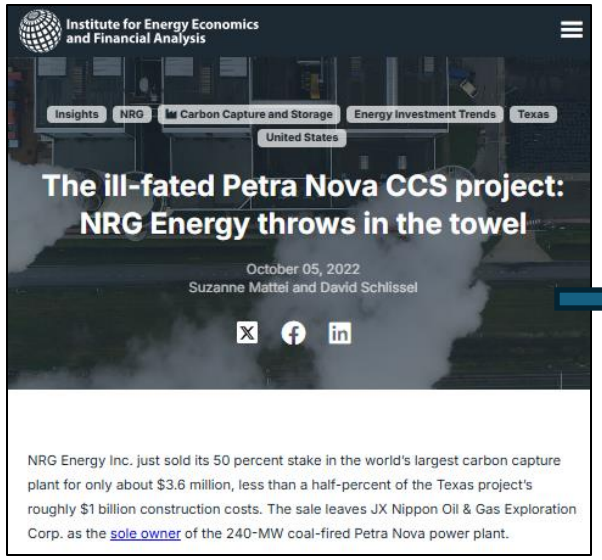
Case Study: Petra Nova (coal + EOR)

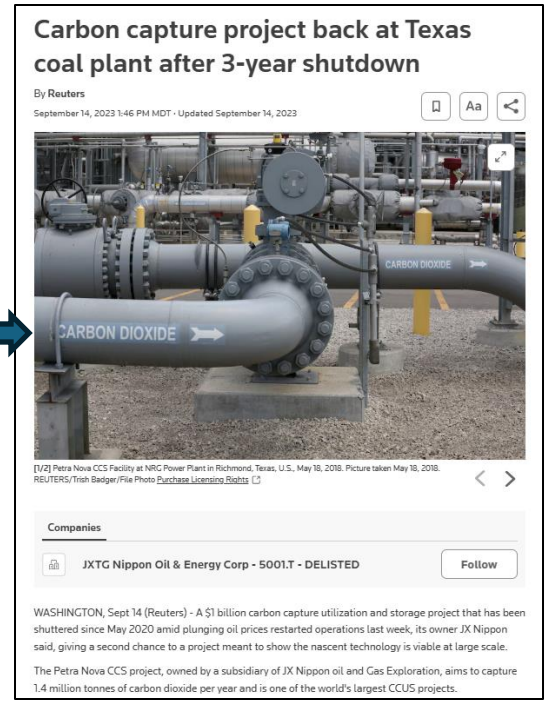
- Location: Thompsons, TX (capture), West Ranch Oil Field (injection)
- Operator: JX Nippon/NRG/Hilcorp
- Geologic setting: Frio Formation
- Distance source to injection: 81 mile (130 km) pipeline
- First Operation: Injection began Jan 10, 2017; closed 2020; reopened Sep 5, 2023
- Status: Operating
- CO_2 stored: 1.4 Mt/year design

- Key Economic Features
  - EOR revenue (2025 enhanced 45Q)
  - Large-scale amine capture

Investment:
(EOR revenue + 45Q for utilization (parity) + Existing pipeline/field infrastructure) – (Capture/Compression + 130-km pipeline + O&M) ± (Oil price/uptime risk) =
Investable when oil prices support cash flow*

GHG mitigation
Net mitigation = (CO_2 stored) – (Energy for capture/transport/injection) – (Upstream CH_4/CO_2) – (Leakage risk)- (Combustion emissions from *incremental* oil) – (Energy/Upstream/Fugitive) ± (Any justified displacement credit)

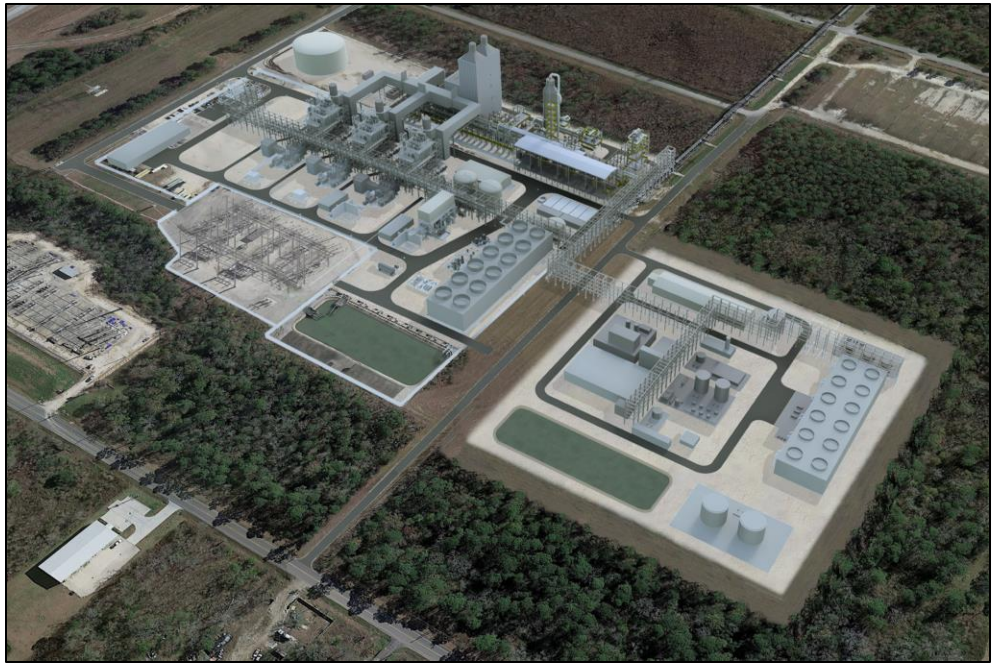




Case Study: Calpine Baytown NGCCC + CCS for power hub

- Location: Baytown, TX, USA
- Operator: Calpine/ExxonMobil LCS
- Geologic setting: TBD
- Distance source to injection: TBD
- First Operation: TBD
- Status: In development
- CO_2 capacity: >2 Mt/year capture

- Key Economic Features
  - Scale: Low-carbon power for industrial loads
  - DOE support withdrawn ($270 M)



Investment:
(45Q for storage + Power/steam revenues + DOE cost-share + Third-party T&S) – (Capture retrofit CAPEX + Energy penalty + Fees for T&S + MRV) ± (Permitting/schedule risk) = **Investable where capture uptime is high and T&S contracts are bankable**

GHG mitigation:
*Net mitigation = (Stack CO_2 × Capture rate) – (generation/energy penalty emissions) – (Upstream gas CH_4/CO_2) – (T&S energy)

DOE cancels $3.7B in carbon capture, decarbonization awards

Calpine, PPL Corp., Ørsted and Exxon Mobil are among the companies affected by the decision.

Published May 30, 2025

Ethan Howland
Senior Reporter

The U.S. Department of Energy on May 30, 2025, canceled $3.7 billion in awards from its Office of Clean Energy Demonstrations, mainly for carbon capture and decarbonization projects. *Ron and Patty Thomas via Getty Images*

DAC + Storage (Oxy/1pointfive STRATOS)

- Location: Ector County, TX, USA
- Operator: Occidental/1pointFive/BlackRock
- Geologic setting: Permian carbonates (San Andres/Queen/Grayburg) ~4,400 ft
- Distance source to injection: onsite
- First Operation: Expected 2025
- Status: In development
- CO_2 capacity: 500,000 t/year capture, 3 wells ~722,000 t/year storage

- Key Economic Features
  - Premium CDR credits + 45Q ($180 for DAC)
  - Integration with Oxy CO_2 network
  - Offtake MOUs with tech firms

Investment:
(45Q for DAC + Premium CDR credit offtakes + Strategic capital) – (DAC CAPEX/OPEX + Class VI storage + MRV) ± (Market/pricing risk for CDR credits, commissioning risk) = Investable with high-value credits and low-carbon energy to power system

GHG mitigation (removal):
Net removed CO_2 = DAC capture – (Electricity/heat for DAC + compression/injection) – (Upstream energy CH_4/CO_2) – (Leakage risk under Class VI MRV)

GEARING UP

Oxy's $1.3B Texas carbon capture facility on track to launch this year

John Egan Sep 12, 2025, 1:00 pm

Vicki Hollub, president and CEO of Occidental, said the company's Stratos DAC project is on track to begin capturing CO2 later this year. *Photo via 1pointfive.com*

Houston-based Occidental Petroleum is gearing up to start removing CO2 from the atmosphere at its $1.3 billion direct air capture (DAC) project in the Midland-Odessa area.

Vicki Hollub, president and CEO of Occidental, said during the company's recent second-quarter earnings call that the Stratos project – being developed by carbon capture and sequestration subsidiary 1PointFive – is on track to begin capturing CO2 later this year.

Sleipner

- Location: Offshore Norway
- Operator: Equinor
- Geologic setting: Utsira Formation, ~800-1000m below seafloor
- Distance source to injection: onsite, on platform separation
- First Operation: 1996 (first commercial offshore CO_2 storage)
- Status: Ongoing injection & 4D seismic monitoring
- CO_2 capacity: >20 Mt by mid 2020s

- Key Economic Features
  - Norwegian CO_2 tax avoidance

Norway's carbon capture and storage projects augur geological risks in global aspirations to bury carbon dioxide

June 14, 2023

Unexpected subsurface challenges at Norway's flagship projects, Sleipner and Snøhvit, show CCS planners and regulators face underground unknowns that may spur financial and environmental risks.

June 14 (IEEFA Asia): Unforeseen variances encountered in the operations of two Norwegian

Investment:
(Avoided CO_2 tax on vented gas + Existing offshore infrastructure) – (Separation/compression + Injection + Monitoring) ± (Offshore O&M/capacity risk) = Investable under Norway's carbon-tax and offshore system

GHG mitigation:
Net stored CO_2 = Process CO_2 injected offshore – (Platform separation/compression energy) – (Upstream energy CH_4/CO_2) – (Leakage risk mitigated by 4D seismic/MRV)

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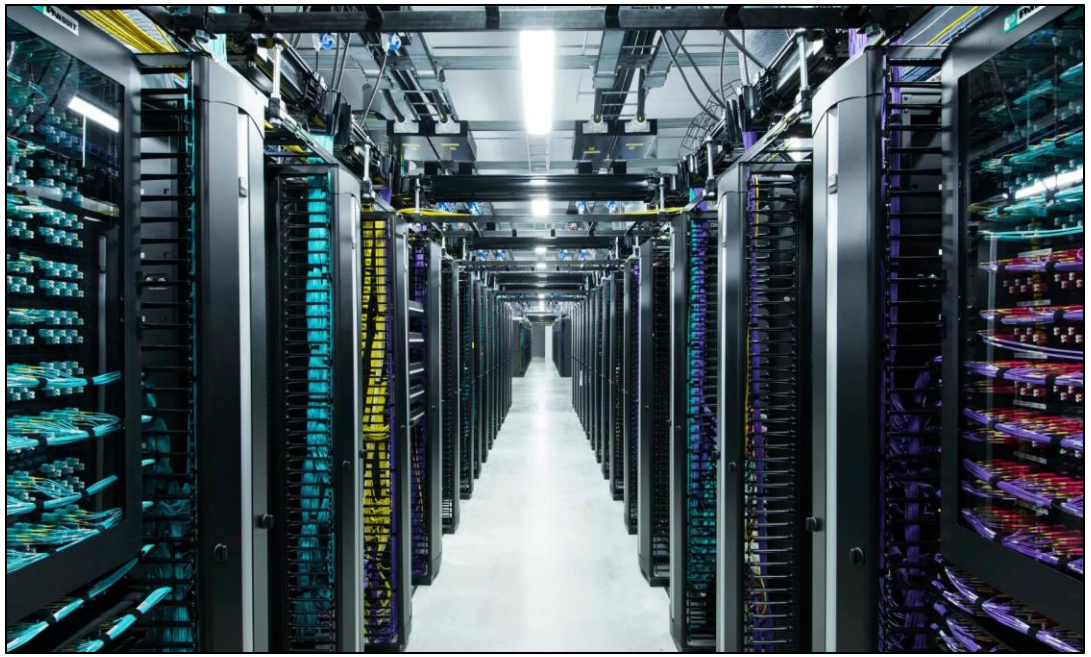
The Changing Landscape

Data Centers and Energy Demand

- Demand for processing power is surging
- IEA projects data-center electricity use doubling by 2030 to ~945 TWh
  - In 2023, US data centers consumed 176 TWh (4% of nation's total electricity)
  - Global usage = 30,634 TWh in 2024
  - Colorado usage = 42 TWh annually
- U.S. grid stress and policy signals (DOE report; PJM/SPP/State measures)
- Concept : Natural Gas with Carbon Capture
  - Reliable power generation + 45Q credits
  - Siting projects considerations



The Changing Landscape

Storage Limitations

- A recent publication significantly lowers the estimated saline storage available for CCUS globally
- Calls for prioritizing CO_2 storage decisions and a comprehensive global strategy for using viable storage space

Managing Uncertainty

- CCUS projects demand patient capital
- Heavy reliance on policy-based incentives is not a strength in volatile political climates

"We've got to rebrand this industry away from the perception of a costly environmental solution toward the reality that we're a more cost-effective, job-creating, economic engine for American leadership and national security"

–Lance Scott, Carbon Capture Machine

Article

A prudent planetary limit for geologic carbon storage

https://doi.org/10.1038/s41586-025-09423-y

Received: 14 August 2024

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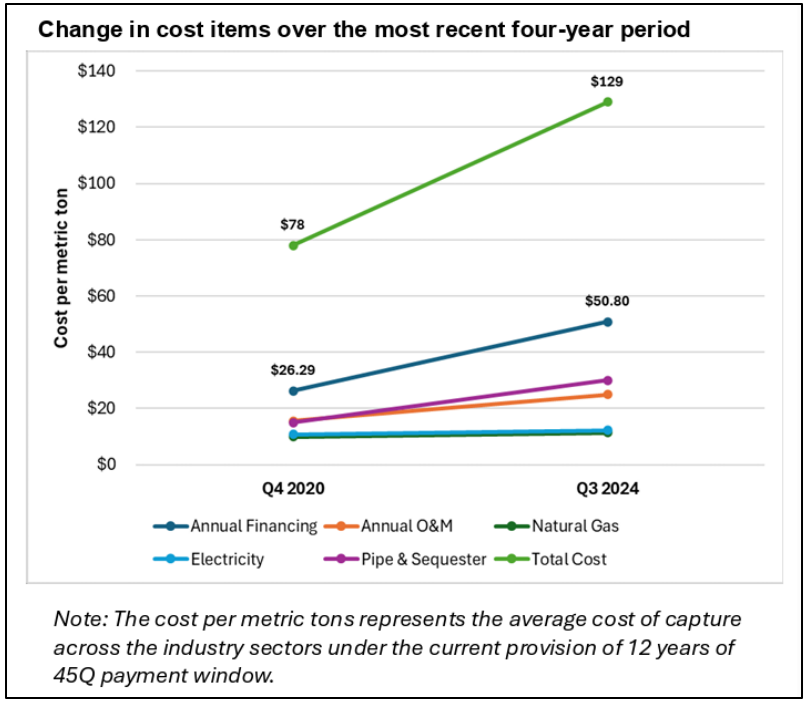
Check for updates

Matthew J. Gidden[1,2✉], Siddharth Joshi[1], John J. Armitage[3], Alina-Berenice Christ[3], Miranda Boettcher[4,5], Elina Brutschin[1], Alexandre C. Köberle[6,7,8], Keywan Riahi[1], Hans Joachim Schellnhuber[1], Carl-Friedrich Schleussner[1,9] & Joeri Rogelj[1,10]

Geologically storing carbon is a key strategy for abating emissions from fossil fuels and durably removing carbon dioxide (CO_2) from the atmosphere[1,2]. However, the storage potential is not unlimited[3,4]. Here we establish a prudent planetary limit of around 1,460 (1,290–2,710) Gt of CO_2 storage through a risk-based, spatially explicit analysis of carbon storage in sedimentary basins. We show that only stringent near-term gross emissions reductions can lower the risk of breaching this limit before the year 2200. Fully using geologic storage for carbon removal caps the possible global temperature reduction to 0.4–0.7 °C (0.35–1.2 °C). The countries most robust to our risk assessment are current large-scale extractors of fossil resources. Treating carbon storage as a limited intergenerational resource has deep implications for national mitigation strategies and policy and requires making explicit decisions on priorities for storage use.



Note: The cost per metric tons represents the average cost of capture across the industry sectors under the current provision of 12 years of 45Q payment window.

CCUS in Context

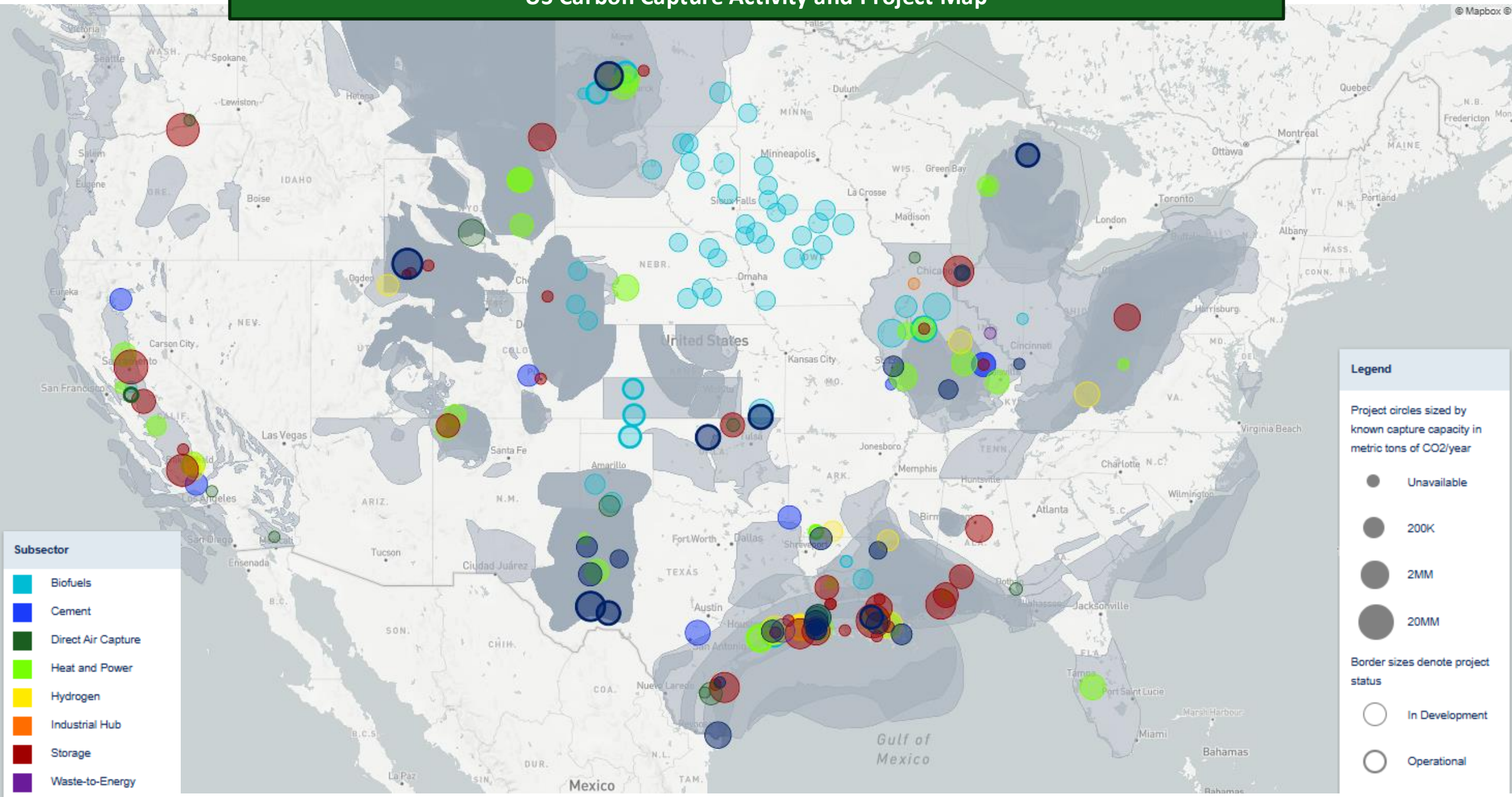
- CCUS is not a panacea but one of many tools
- In US politics, carbon management finds itself in a unique position
- Project economics are still king and are very site-specific
- Capture, Transport and Storage innovation continues to improve economics

Takeaway

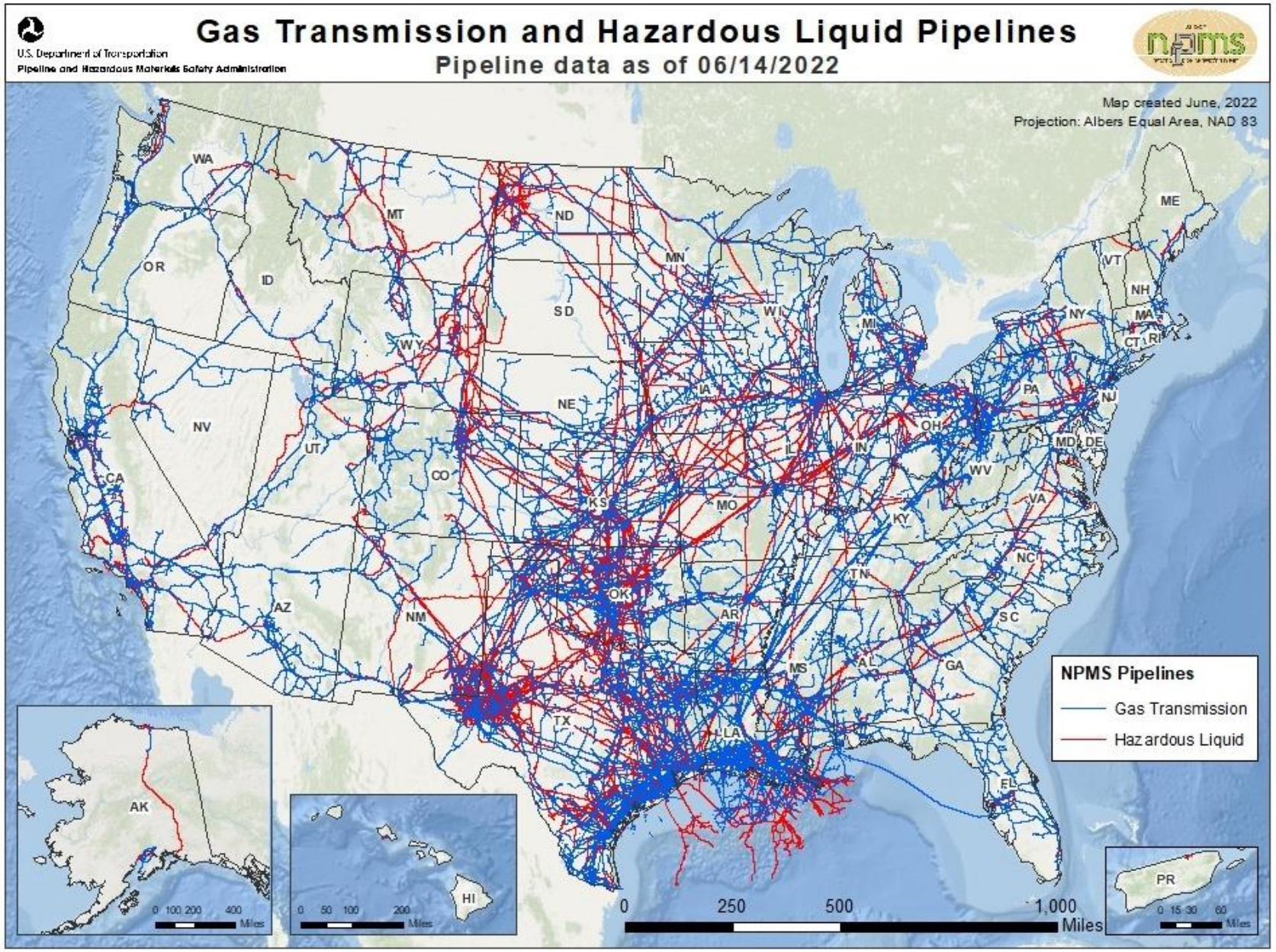
- You can make a strong business case for CCUS when
  - Storage is close
  - Incentives stack
  - Off takers pay a premium
  - Low-carbon power is valuable (to society and to investors)

Thank you!

US Carbon Capture Activity and Project Map



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