7-Point CCUS Strategy Guide

Exclusively for teams navigating carbon capture markets

decarbonfuse

*Excerpt from the authors' "**Navigating CCUS**" workshop*

About the authors

PK Pande

PK's deep knowledge and world class expertise encompasses delivery of commercial / technical solutions for CCUS, gas injection, EOR-CO_2, new and mature field development, unconventional resources, conceptual studies, and systems integration. He has served as Chief Engineer for QEP Resources and Director, Reservoir Technology with Anadarko Petroleum Corporation. He held key reservoir and production engineering technical roles with Total and British Petroleum. He served as Society of Petroleum Engineers (SPE) Distinguished Lecturer on "*Shale Resources — A Full Life Cycle Integrated Approach* ".

Mr. Pande holds a Bachelor of Science in Chemical Engineering from the University of California, Berkeley and MS in Petroleum Engineering from New Mexico Institute of Mining and Technology. He is a Registered Professional Engineer in the State of Texas.

Todd Bush

Todd is advising project developers, midstream operators, and ethanol producers on carbon capture (CCUS, DAC, BeCCS) efforts while developing commercial strategies for emerging energy markets, like hydrogen.

He was previously Head of North America for Westwood Global Energy serving the onshore energy supply chain and led due diligence transactions for equipment, well services, and software companies. Prior to Westwood, he led digital oilfield, environmental, lean six sigma, and competitive intelligence initiatives for Chevron's Lower 48 business unit.

Mr. Bush holds a Bachelor of Business Administration in Information and Operations Management from Texas A&M University and MBA from Rice University.

Questions to consider for CCUS

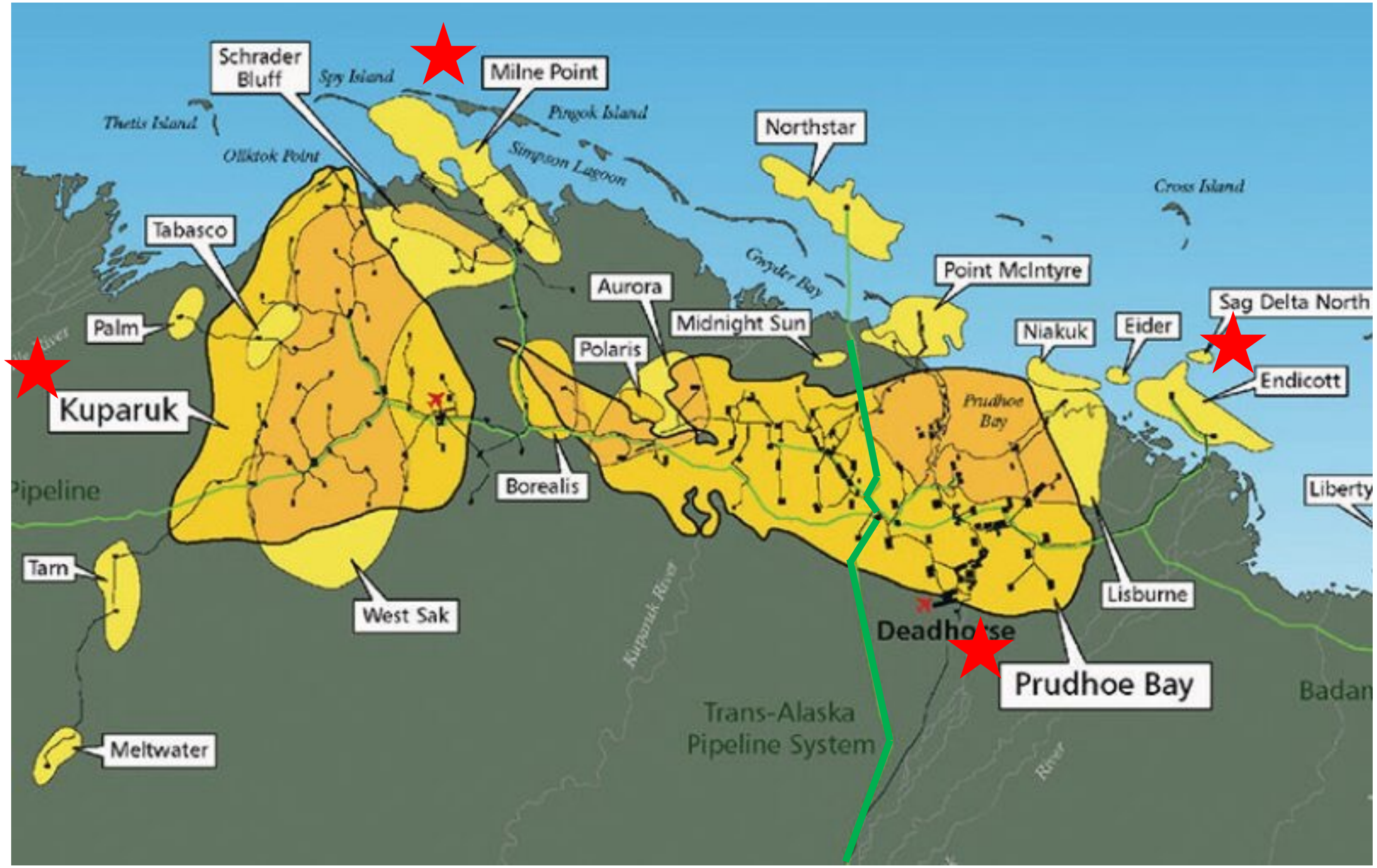
- **What has industry learned from CO2 EOR?**
- What are we already confident with today?
- How do we think about full lifecycle economics?
- What does the market look like today?
- How are pore space regulations developing?
- How do we take advantage of 45Q?
- How do we stay on track for Class VI well permits?

What has the industry learned?

What Has CO2 & Miscible Gas Injection EOR Already Taught Us For CCUS?

- Historical Context
  - Decades of Gas injection
- Miscible Gas Injection Processes Alaska
- CO2 Miscible EOR Permian
- Naturally Occurring CO2 (NM, CO)
- Timing
  - 1960s - Research
  - 1970s – Initial Permian Implementations
  - 1980-90s – Alaska Projects, Expansions
- Other Key Areas
  - Algeria, Berkine Basin
  - North Sea, Norway

What has miscible gas injection EOR taught us for CCUS?

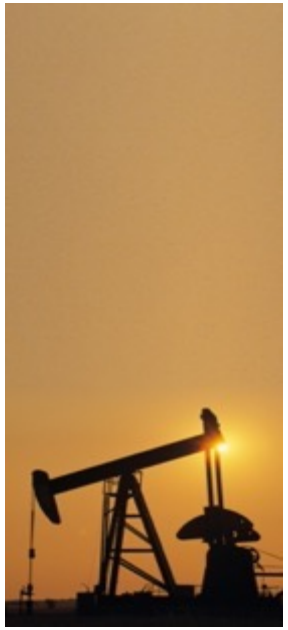


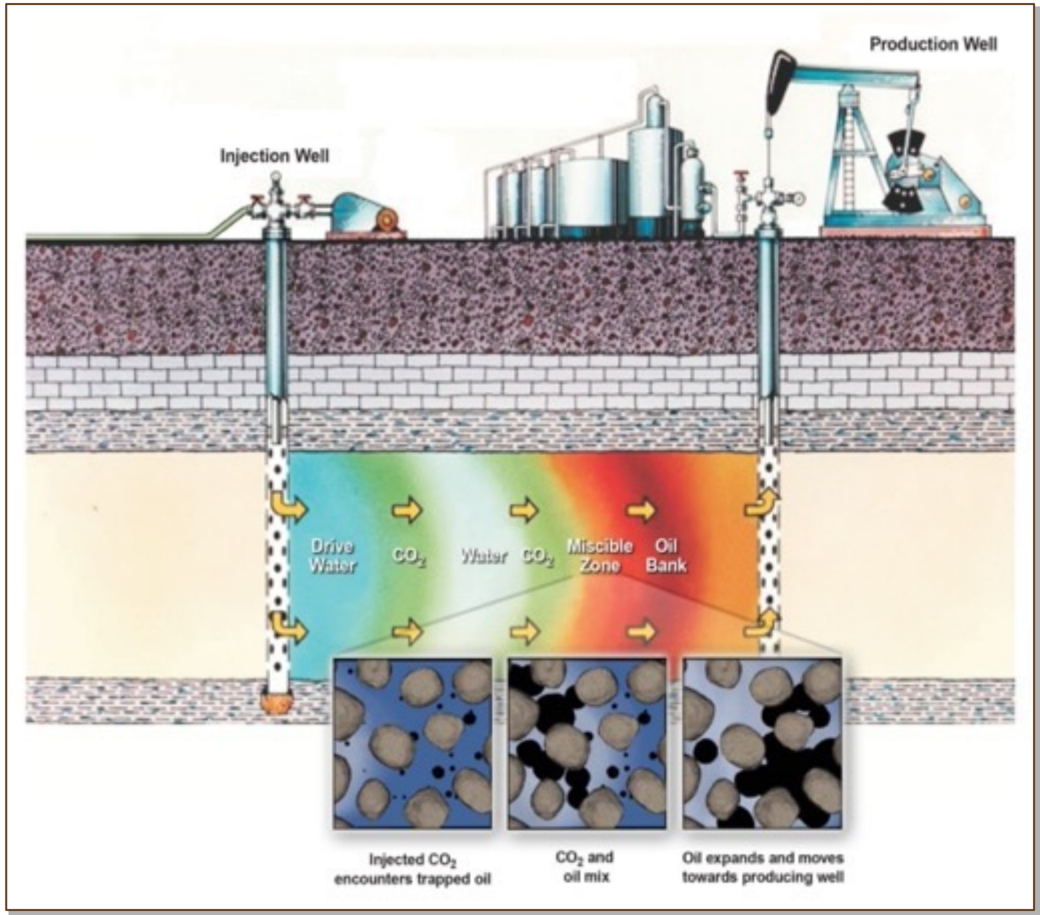
Multiple Projects

- Prudhoe
  - Largest EOR Worldwide
- Endicott
  - First Arctic Offshore EOR

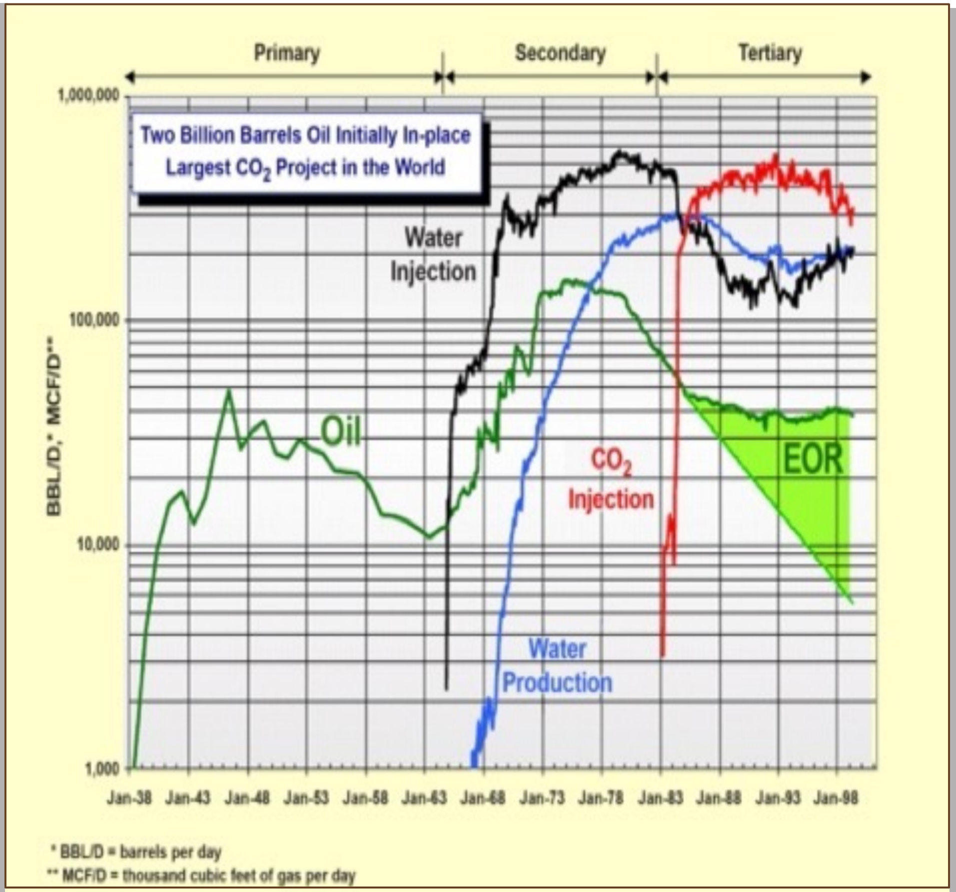
★ Hydrocarbon Miscible Gas Projects for EOR In Oil Fields

What has CO2 EOR already taught us for CCUS?





Water Alternating Gas (WAG) Process

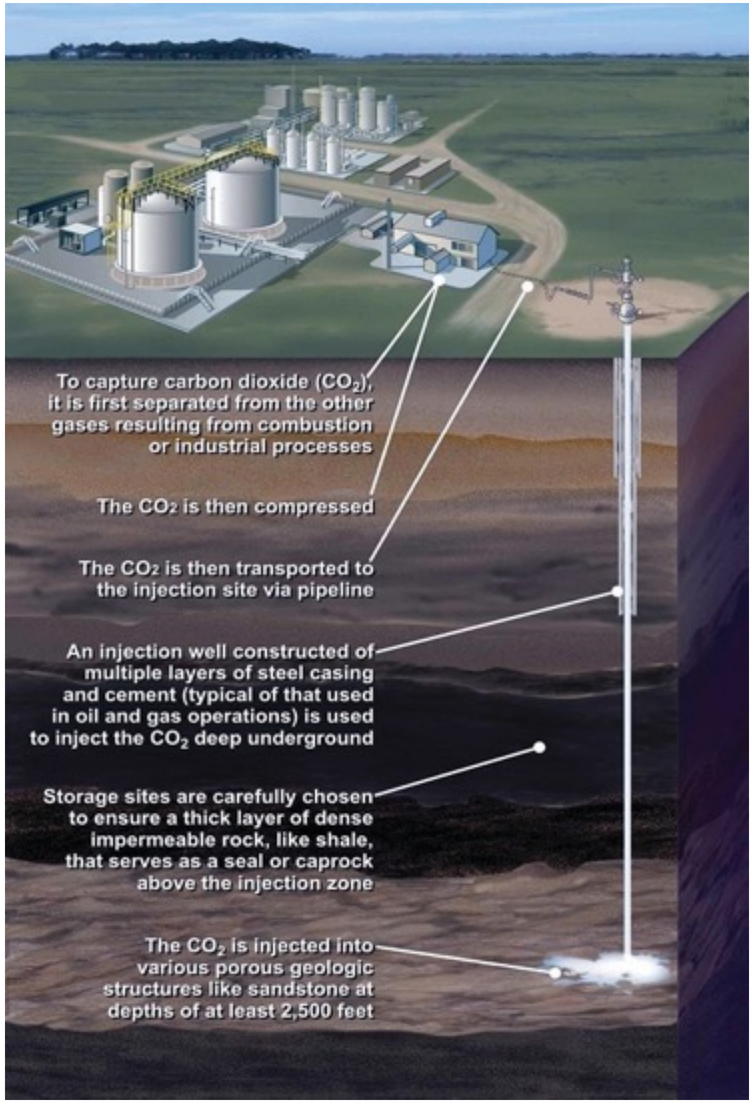


Additional Oil Recovery

Questions to consider for CCUS

- What has industry learned from CO_2 EOR?
- **What are we already confident with today?**
- How do we think about full lifecycle economics?
- What does market look like today?
- How are pore space regulations developing?
- How do we take advantage of 45Q?
- How do we stay on track for Class VI well permits?

What are we confident with CCUS projects?



- Transferable technologies
- No caprock breaches
- Time-Scales of concern
- External boundaries
- Sweep efficiency
- Source of CO2 differs
- Economics differ in CCUS/EOR
- Carbon Neutral Oil from CO2-EOR
- Complementary technologies

Questions to consider for CCUS

- What has industry learned from CO2 EOR?
- What are we already confident with today?
- **How do we think about full lifecycle economics?**
- What does market look like today?
- How are pore space regulations developing?
- How do we take advantage of 45Q?
- How do we stay on track for Class VI well permits?

Workflows for CCUS market participation

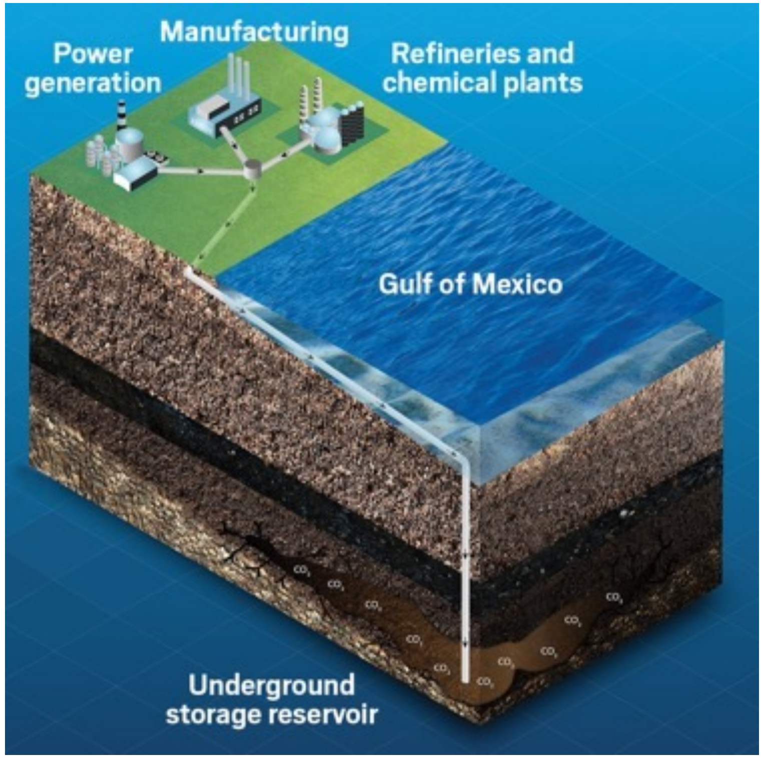
1 Capture

Emissions Characterization
- Volumes, Long-Term Outlook
- Processing
- Point Source, Mini-Hub, Hub
- Long-term

3 Pipeline Transport

Infrastructure
- Sizes, Rates, Networks
- Compression

5 Costs / Economics



4 Well Construction

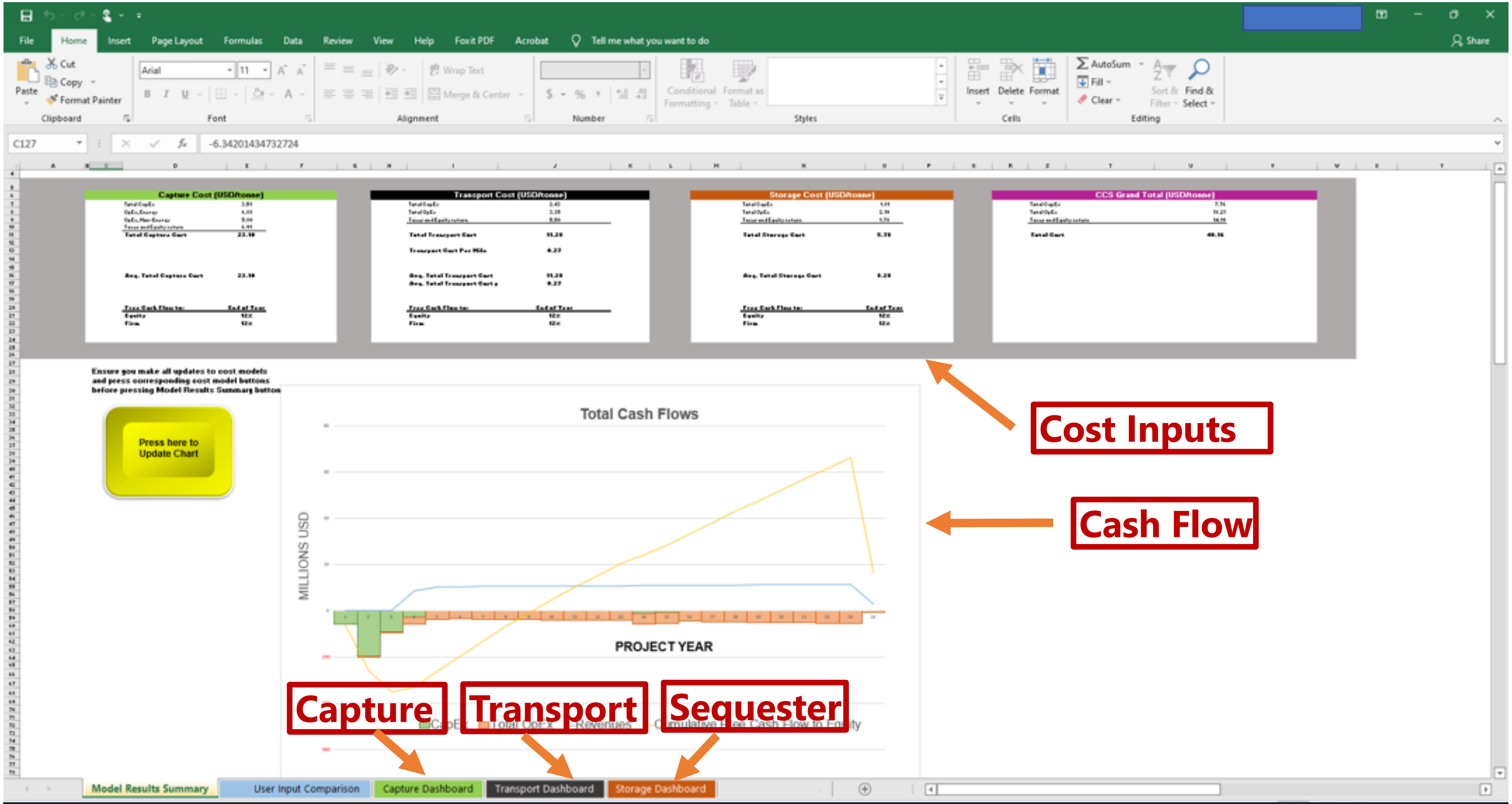
Well Count
- Timing
- Injectivity
- Regulatory (Class VI Permits)

2 Subsurface Storage

Number & Size of Projects
- Development Timing
- Reservoir Condition Requirements (Depth, P, T)
- Distance from Shore

Petroleum Systems Based Commercial Approach

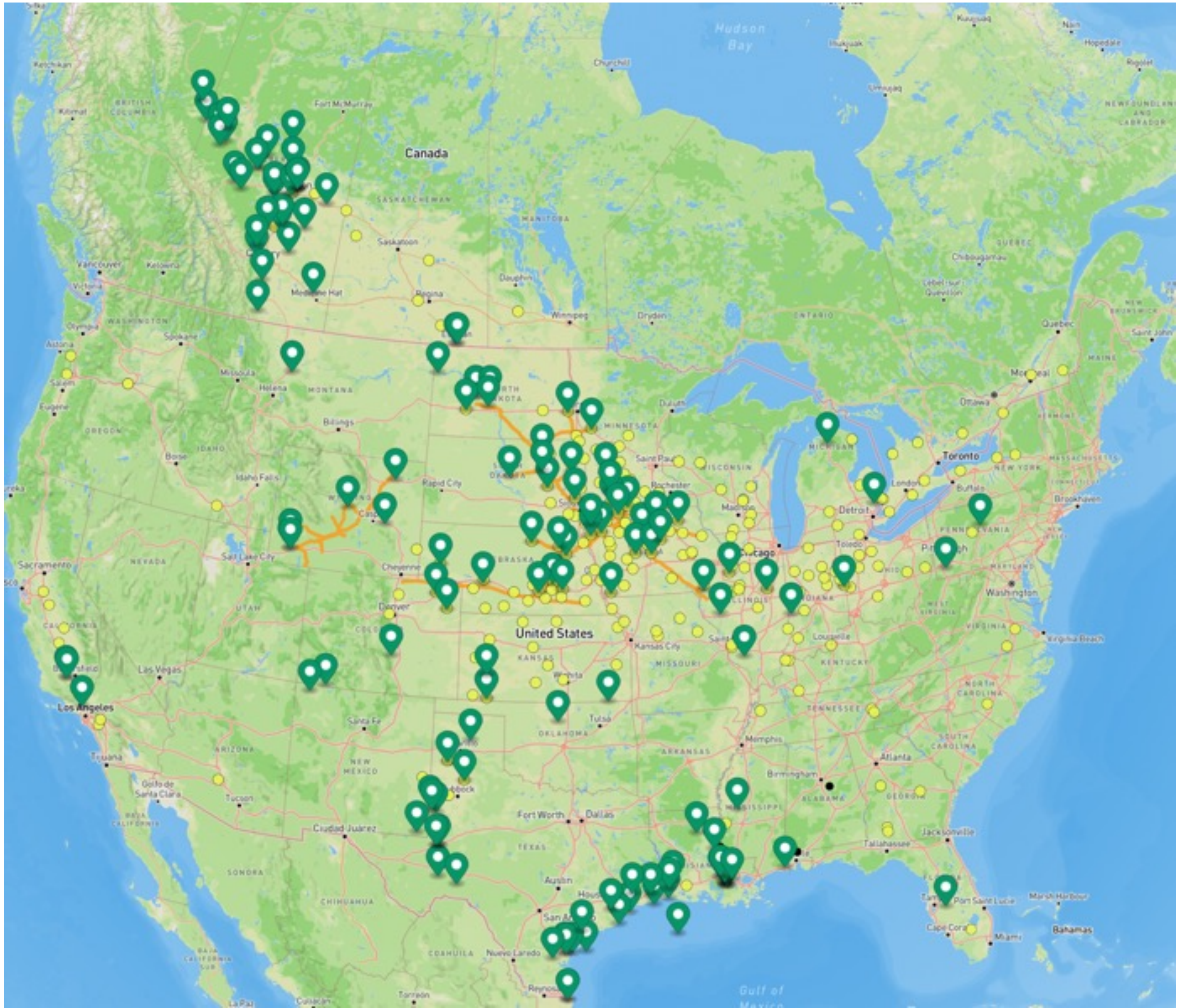
Full lifecycle evaluation & economics



Questions to consider for CCUS

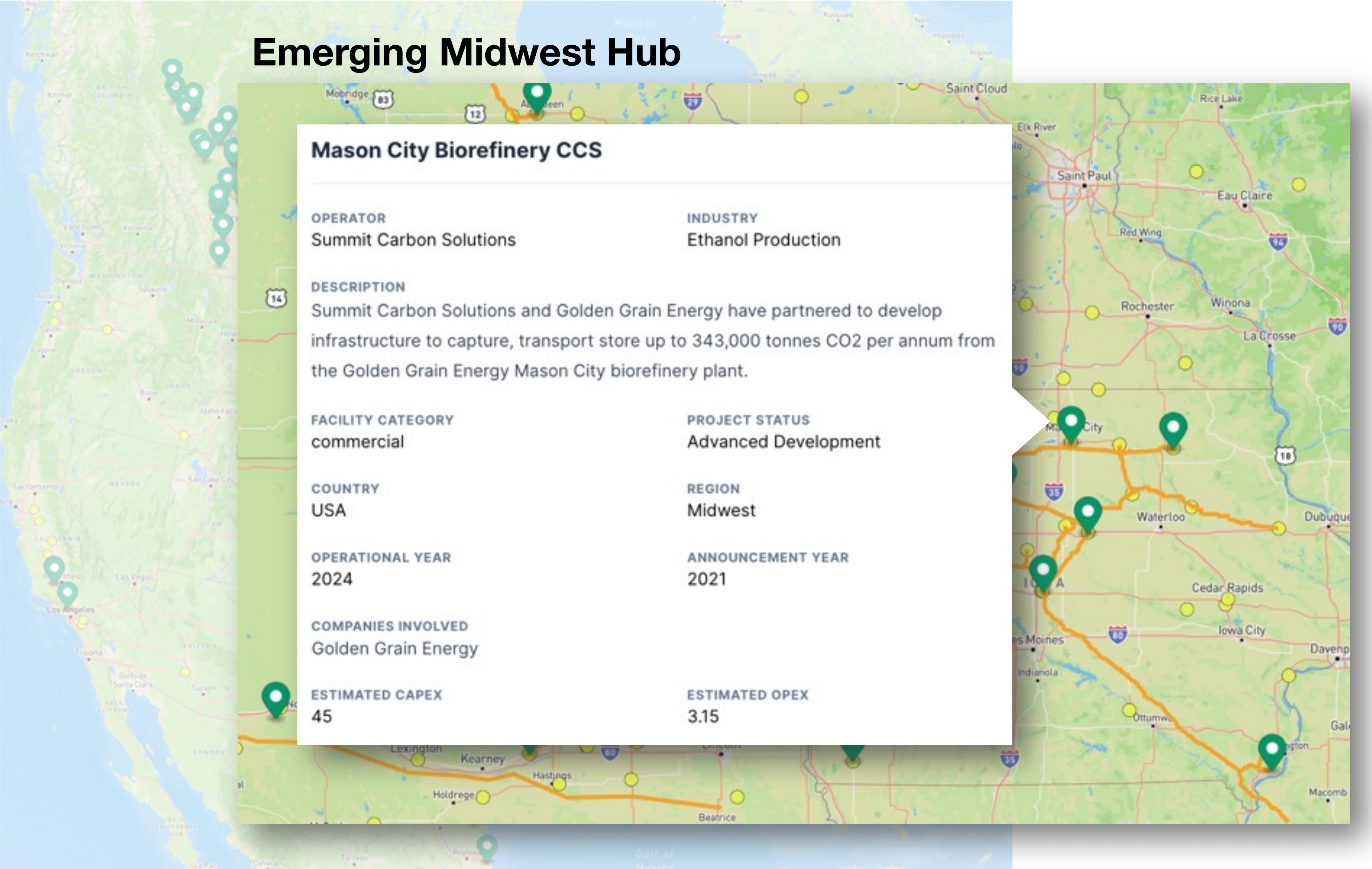
- What has industry learned from CO2 EOR?
- What are we already confident with today?
- How do we think about full lifecycle economics?
- **What does market look like today?**
- How are pore space regulations developing?
- How do we take advantage of 45Q?
- How do we stay on track for Class VI well permits?

ProjectDB - North America CCUS + DAC facilities



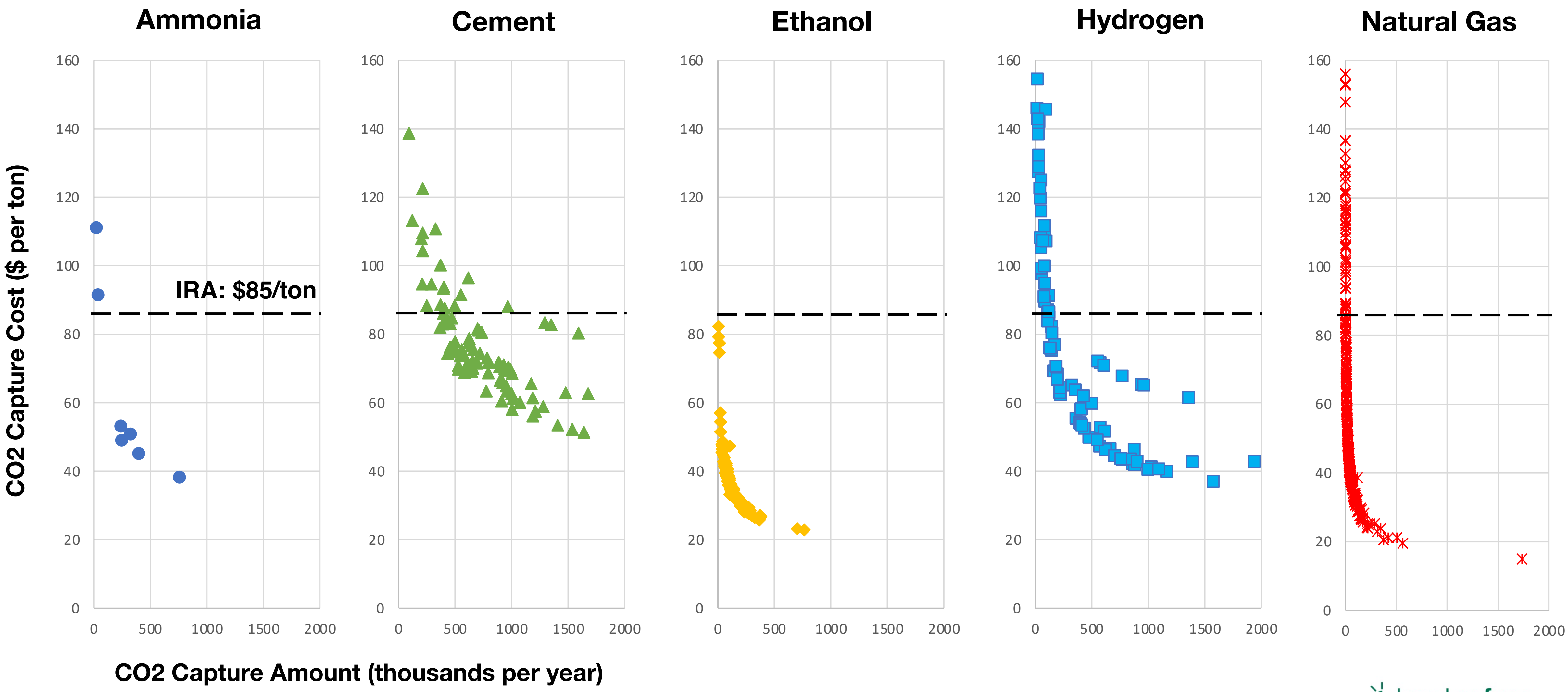
- Over 150 carbon capture projects
- Concentration of projects in Gulf Coast, Permian, Midwest, Rockies, and Alberta
- Proposed CO2 pipelines
- Map excludes pilot projects
- Excludes micro-carbon capture like CCS from buildings

ProjectDB - North America CCUS + DAC Facilities



Range of CO2 capture costs

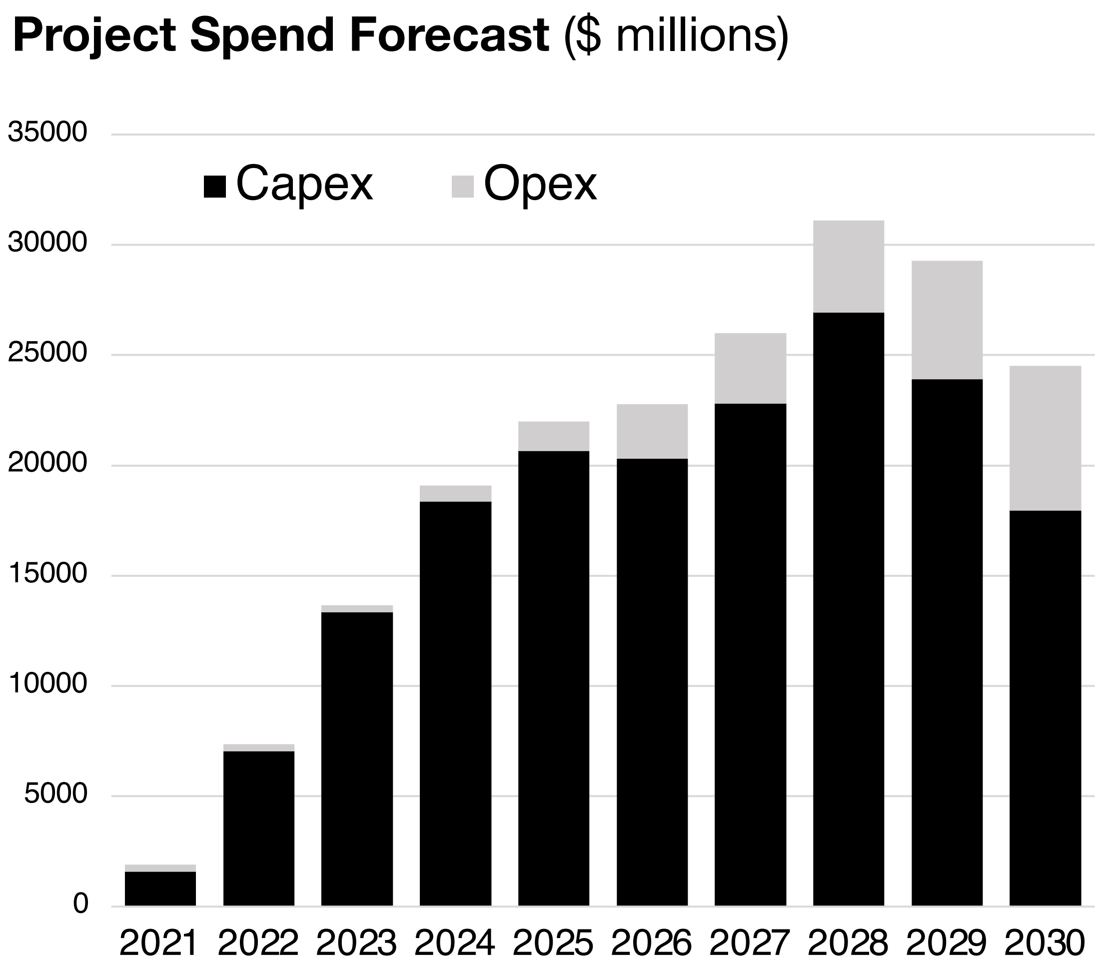
Facility assumptions in the methodology derived from facilities in each segment.



decarbonfuse

Carbon capture capex to $13 billion in 2023

Announced projects have $33 billion in capital spend from 2022 to 2027 (black in chart).



- Capex and Opex included for known projects and forecasted activity by CO2 source
- Spend peaks at just over $30 billion in 2028
- Decline in activity spend in 2029 and 2030 due to availability of lower cost CCS projects
- Excludes pilot project spending

Questions to consider for CCUS

- What has industry learned from CO2 EOR?
- What are we already confident with today?
- How do we think about full lifecycle economics?
- What does market look like today?
- **How are pore space regulations developing?**
- How do we take advantage of 45Q?
- How do we stay on track for Class VI well permits?

Pore space ownership uncertainty

Most states remain unsettled but legal teams are pointing towards Wyoming and North Dakota as proposed solution.

State	Pore Space Owner	Notes
Colorado	Unclear	Likely Federal government. Colorado courts have not addressed yet.
New Mexico	Surface Owner	Older case law points to surface ownership, but state and public entities have right to use aquifer storage.
North Dakota	Surface Owner	
Texas	Unclear	Multiple cases in Texas offer conflicting results. Watch Myers-Woodward case arguments.
Utah	Unclear	Pore space right in initial stage of development
Wyoming	Surface Owner	

Notes from Graves, Dougherty, Hearon, & Moody Mineral Owner Meeting November 2022.

Questions to consider for CCUS

- What has industry learned?
- What are we already confident with today?
- How do we think about full lifecycle economics?
- What does market look like today?
- How are pore space regulations developing?
- **How do we take advantage of 45Q?**
- How do we stay on track for Class VI well permits?

What does 45Q tax credit really mean?

45Q Post-IRA offers increased sequestration tax credit with wage and apprenticeship constraints

	45Q Pre-IRA	**45Q Post-IRA**
Construction Start	2026	2033
Sequestration Credit	$ 50/Ton (2026)	$ 85/Ton
EOR Credit	$ 35/Ton (2026)	$ 60/Ton
Wage, Apprenticeship Requirement	None	Applies
Direct Air Capture (DAC)	$ 50/Ton (CCS) $ 35/Ton (EOR)	$ 180/Ton (CCS) $ 130/Ton (EOR)

What does 45Q tax credit really mean?

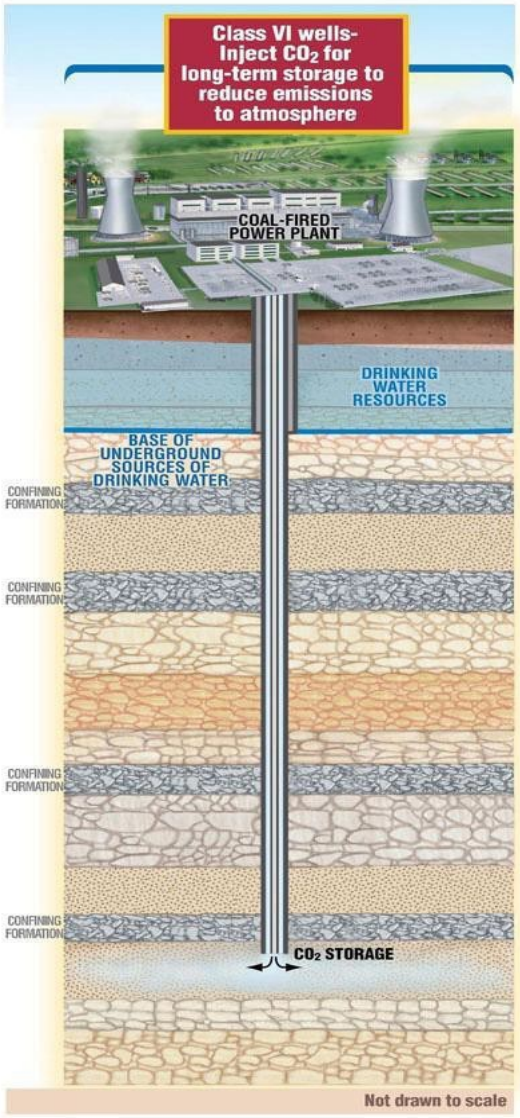
45Q Post-IRA offers increased sequestration tax credit with wage and apprenticeship constraints

	45Q Post-IRA
Direct Pay	12 Year Credit; State Local Governments, Tribes, TVA, Electric Coops, Tax Exempt Entities 5 Year Credit; Everyone Else
Transferability	Taxpayer can Transfer, Sell 45Q to Unrelated Party
Private Action Bonds (PAB)	Allows CCS Facility Financing with PABs With 15% 45Q Credit Reduction

Questions to consider for CCUS

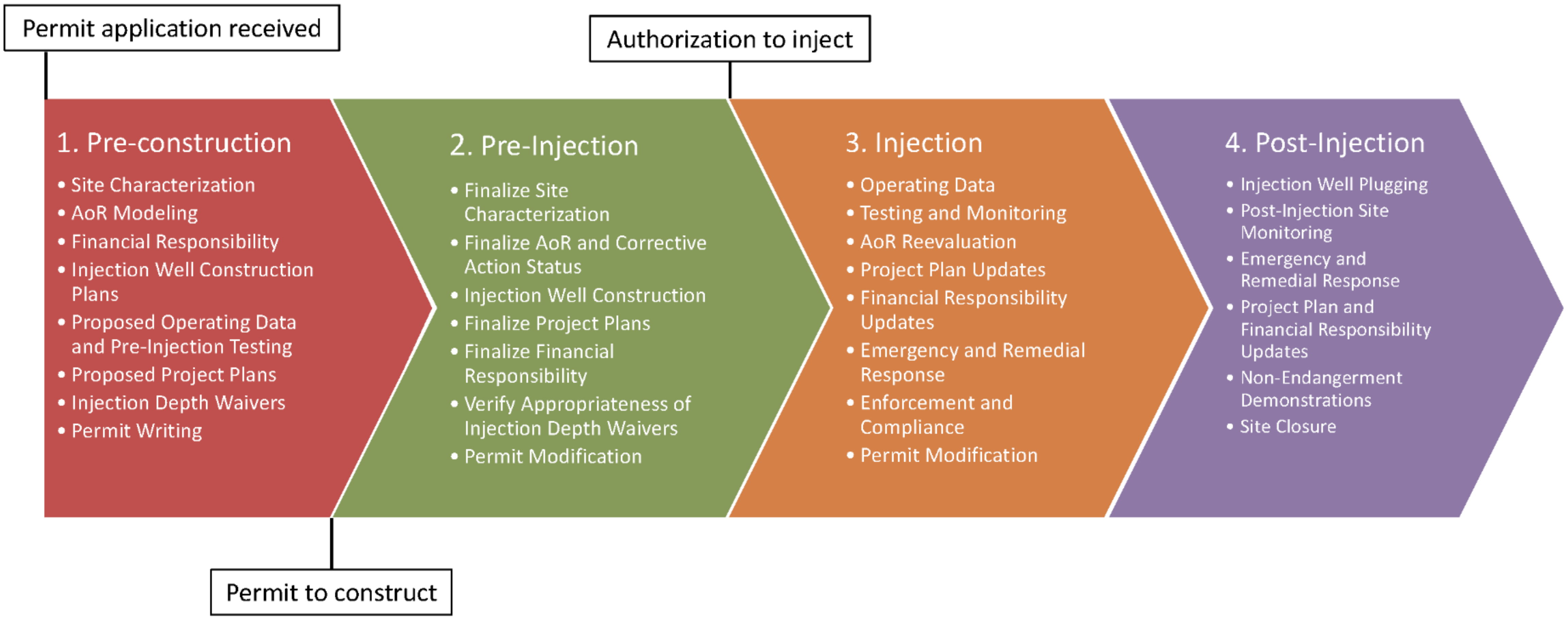
- What has industry learned?
- What are we already confident with today?
- How do we think about full lifecycle economics?
- What does market look like today?
- How are pore space regulations developing?
- How do we take advantage of 45Q?
- **How do we stay on track for Class VI well permits?**

What are the regulatory challenges?



- **Approval authority:**
  - EPA regulates Class VI permit approvals
  - Wyoming, North Dakota have primacy
- **Authority:**
  - Decentralization of authority
  - Expected to de-bottleneck, speed approvals
  - TX, LA, WV, AZ have applied for primacy
- **Active Permits**
  - Only two Class VI permits approved
  - Archer Daniel Midland, CO2 injection1.3 Mtpa
  - 4 years - filing to final approval.
- **Timing expectations**
  - Needs to improve, will still take ~ 2 Years
- **Class VI: Permitting, Operational Requirements, Due Diligence**
  - Site Characterization, Data Needs
  - Area of Review (AoR)
  - Plume Projections, Site Monitoring

What is the permitting process?



Workshop content

Landscape

Introduction, Overview
- Basics of CCUS
- Methods & Mechanisms

North America & Global Projects
- Key Learnings

Announced Projects
- Key Insights

Commercial

Pore Space Valuation
- Storage Resource

Offshore Leasing
- Status, Key Issues

Costs, Economics
- Project Screening

Public Policy
- Section 45 Tax Credit

Project Management
- Development Planning, Timing

Supply Chain
- Key Considerations

Risk Analysis
- Red Flags

A Comprehensive, Briefing Enabling Discovery of New, Powerful Insights

Development

North America Storage
- Key Onshore Basins
- GOM Saline Aquifers

Emissions
- Characterization - Geographical, Industry
- Handling, Process Engineering

Regulatory
- Class VI Well Permitting

Transportation
- Pipeline Networks & Engineering

Workflows
- Integrated Systems Processes, Workflows

Full-day or half-day depending on needs.

Questions to Consider for CCUS

- What has industry learned?
- What are we already confident with?
- How do we think about full lifecycle economics?
- What does market look like today?
- How are pore space regulations developing?
- How do we take advantage of 45Q?
- How do we stay on track for Class VI well permits?

Contact Todd Bush at todd@decarbonfuse.com

decarbonfuse

Solving industrial decarbonization with carbon capture, hydrogen, electrification, and carbon removal intelligence.

decarbonfuse.com

INVESTORS	G, Ara Partners, KEIKI, Keyframe, CLEARSTREAM CAPITAL
ASSET OWNERS	Chevron, ExxonMobil, bp, Denbury, TALOS ENERGY
SERVICE & EQUIPMENT	CATERPILLAR, PATTERSON-UTI, NABORS, Linde, subsea 7
MINING	BHP, AtlasSand, COVIA, APOLLO GROUP
ENGINEERING & GEOSCIENCES	XODUS, Guidehouse, PENSPEN, Dsider, SCA Subsurface Consultants, VELROC

10+ We're an experienced network of **10+ expert energy associates**

We have a **global reach** with analysts in Argentina, Nigeria, Dubai, India, Australia, and UK.