De-risking First-Mover Secure Geologic Storage

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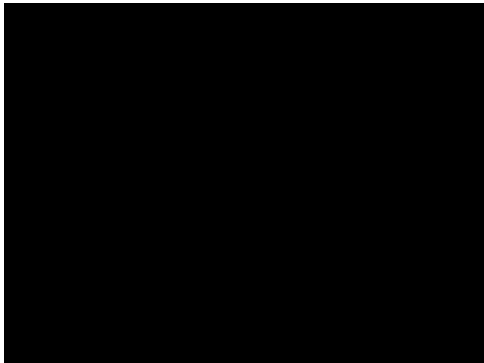
US Energy Association Webinar:
CO_2 Storage, Optimizing Large-Volume First-Mover Projects By Managing Short- and Long-Term Security and Li
September 15, 2021

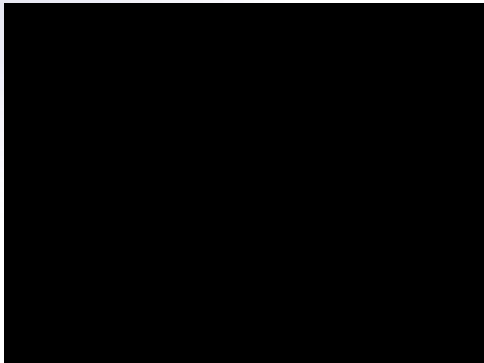
De-risking First Mover Secure Geologic Storage

Outline

I. Background and “The Grand Challenge”
II. Necessity of CCS and CCUS
III. Site Selection - Putting CO_2 in the Right Geologies
IV. EOR & “Dialing In” Low Carbon Oil
V. The Volumetrics and $ Involved: The Best Sites First
VI. Summary



I. Background and “The Grand Challenge”



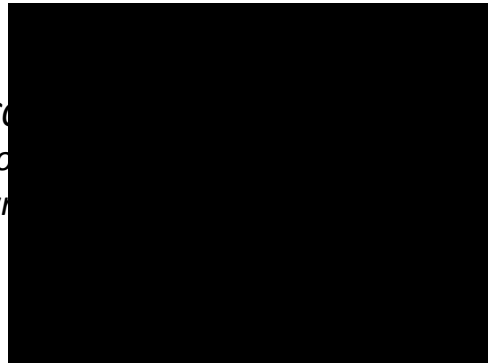
Handy Conversion Factoids and Factors

- Oil & Gas Industry typically uses surface volume metrics
- Sequestration (storage) industry typically uses "mass" for their metrics
  - Conversions
    - 1 (english) ton CO_2* ~ 17.5 mcf (mcf = 1000 cubic ft)
    - 1 metric ton = 1.1 english tons ~ 19.25 mcf
    - 50 million cf/day ~ 1 million tons per year**

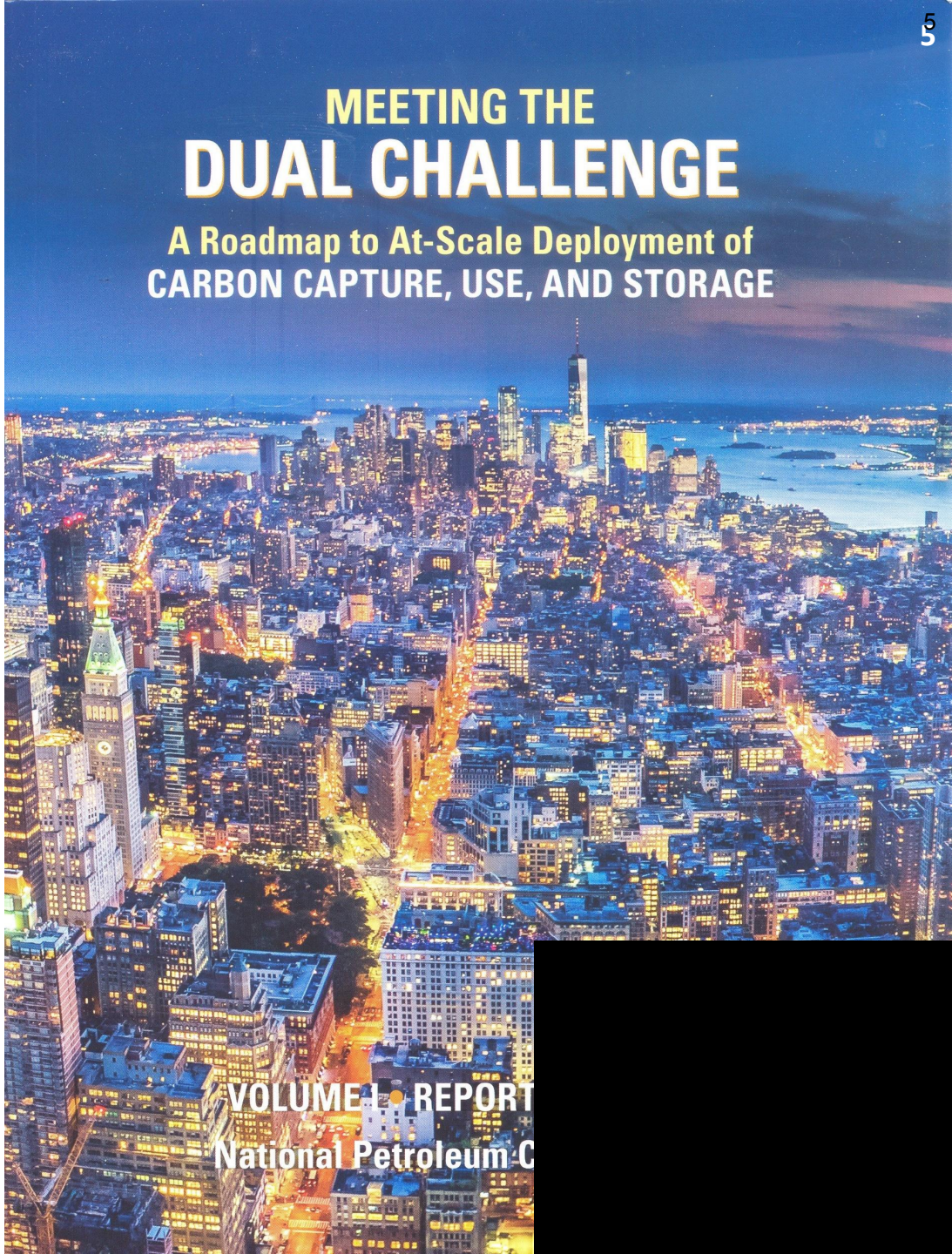
** Usually 95% purity (or greater) of C*

*** The magnitude of 'new' CO_2 injectio*

2.5-3.0 bcf/day or 50-60 Million tons/y



Industry Taking on the Challenges (1)



Industry Taking on the Challenges (2)

The API has been forced to confront its resistance to regulatory action on climate change. A few of its European members left the lobby group due to disagreements over its climate policies and support for easing drilling regulations. In addition, the Biden administration is pursuing a policy agenda that would shift the U.S. off of fossil fuels.

A draft statement of the policy shift reviewed by the Wall Street Journal said the group does not endorse a specific carbon pricing tool such as a tax on carbon emissions or emissions trading scheme. The source said, however, that the group's State of American Energy report released in January was supportive of a market-based carbon pricing policy.

API Statement On Social Cost Of GHG Emissions

202.682.8114 | press@api.org

WASHINGTON, February 26, 2021 – The American Petroleum Institute (API) today responded to the Biden administration's announcement to update the social cost of greenhouse gas (GHG) emissions and signaled the industry's commitment to working with the administration to shape a lower-carbon future.

"As the U.S. works to achieve a lower-carbon future, assessing the social cost of greenhouse gas emissions in an effort to drive emissions down is an important step in policymaking," API Vice President of Corporate Policy Stephen Comstock said. "We look forward to working with the interagency working group and providing input as they develop their final recommendations, and we encourage the administration to pursue a transparent process for stakeholder engagement. This is an opportunity for government and industry to work together t our shared goals of reducing the risks of climate change and building c progress our country has made in driving down greenhouse gas emissi

API recently joined other trade organizations in sending a letter to the administration expressing the regulatory community's interest in parti this process.

Big Oil and the Energy Transition

"We are not afraid of the transition out of oil and gas, because we're a part of that transition," said Vicki Hollub, Oxy's chief executive officer. "I do believe that in 15 to 20 years, more of our income will be from carbon management than from oil and gas."

Oxy Becomes First U.S. Driller To Announce Net-Zero Plan

By Charles Kennedy - Nov 11, 2020, 9:30 AM CST

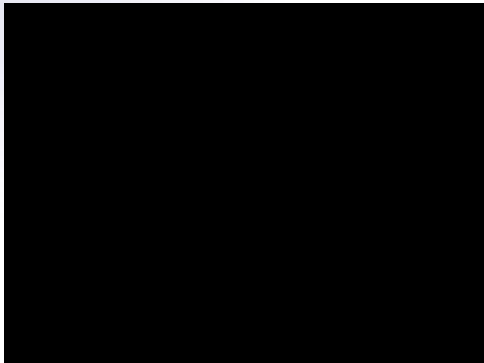
Occidental Petroleum has become the first U.S. oil company to announce a plan to slash greenhouse gas emissions to net-zero by 2050.

In a five-minute video, Oxy cited its expertise in enhanced oil recovery, which features carbon dioxide injection into oil wells, as well as experience with carbon capture technology, which, according to the company, position it at the forefront of emission-cutting efforts.

One of the biggest users of carbon dioxide, currently stores some 20 million tons of CO the Permian every year. This amount, the c offsets the emissions from more than 4 mill

II. Necessity of CCS* and CCUS

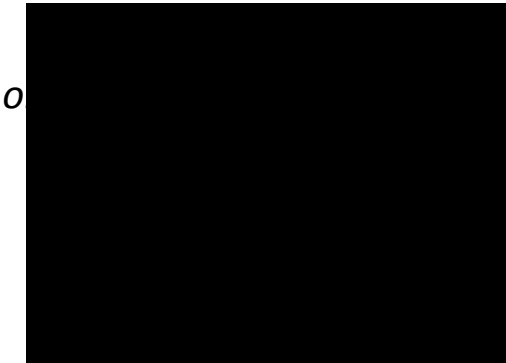
* Many refer to CCS as to include CO_2 Storage while Producing a Product – we prefer to distinguish between the two and use CCUS when treating CO_2 as a commodity



CCS and CCUS

- CCS: Carbon Capture and Storage
  - Captured 'Waste' CO_2 Injection – all projects to date at small scale and without any producing wells
- CCUS: Carbon Capture Utilization and Storage
  - During Injection, produces a product as in oil during CO_2 EOR* or CO_2 Nat'l Gas Enhanced Recovery
  - Reservoir Pressures are Carefully Controlled and Regulated not to Exceed Pressure Limits Established for State Oil and Gas Regulatory Agencies
  - Historically CO_2 EOR has been an Active Process for Five Decades while Storing an Estimated Amount of new CO_2 Exceeding 20 trillion cubic feet (400 billion metric tons) and produced over 2 billion bbls of oil
  - Current rates of Purchased (aka "new" i.e., non-recycled) CO_2 injection approach 2.5 billion cubic feet per day (50 million tons per year)

** In a Large EOR project we can assume >95% of 'new' (i.e., captured o*
permanently stored in the reservoir



Source: www.greenbiz.com/article/why-we-need-ccs-any-cost

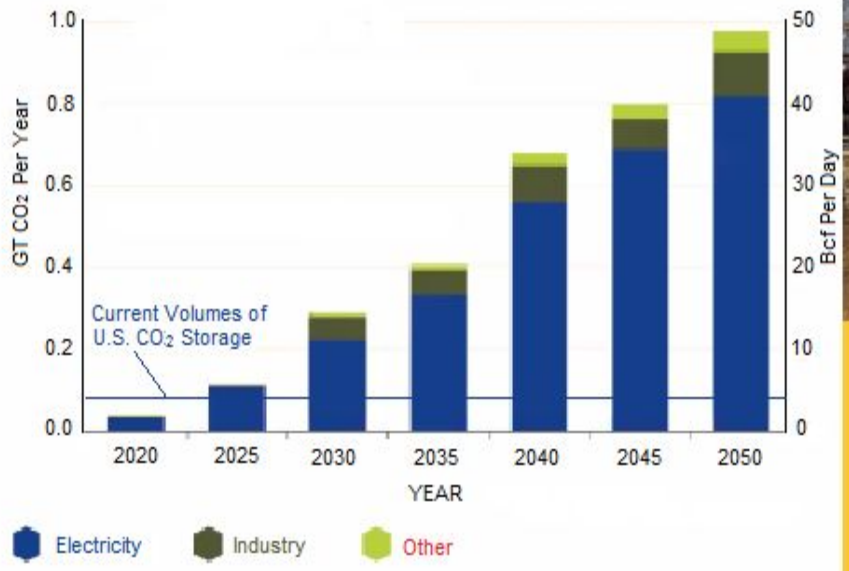
- The acceleration of carbon capture storage (CCS) technology deployment is a critical factor within this agenda. CCS is a critical component of any sustainable energy and greenhouse gas policy. It is not the only one –we need energy efficiency solutions, renewable energy options and more nuclear. But we also need CCS because of our continuing reliance on fossil fuels.
- If there is no CCS, we will be in very dire straits. Because there are some very important economies for which we cannot expect a drop in the use of coal, for example: the United States, China, Russia, South Africa.

CLIMATE WEEK NYC

Shell's Forecast for US Carbon Capture Storage Rates

Deploy carbon capture, utilization and storage at scale

CO_2 Emissions Captured by CCS from all US Energy

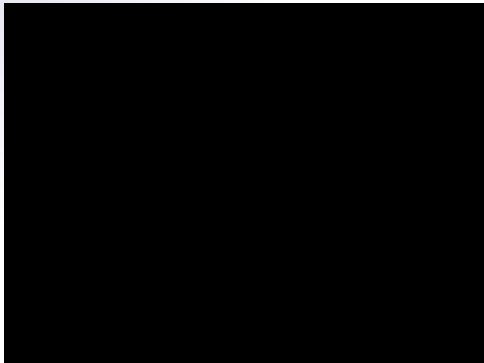


Adapted from Shell International Pesentation -2020

A US net-zero CO_2 energy system by 2050

- CCUS is essential, e.g. industrial processes, bio-energy power generation, gas-fired power generation and direct air capture
- Build one major US CCUS facility every 3 months until 2050 (each capturing more than 8 million metric tons per year)
- Utilization of captured CO_2 is import
  permanent (or near-permanent) stora

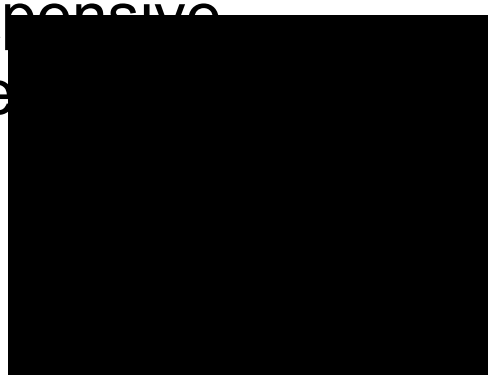
III. Site Selection - Putting CO_2 in the Right Geologies



Many Geological Sites face Issues with Buoyant Fluids Migrating in the Subsurface and Finding a Pathway to the Surface

- As We've Seen, We Need CCS for Our Future but we are Dealing with Very Large Volumes of Injection During CCS
- Projects to Capture CO_2 from Large Industrial Plants are Very Expensive Projects and Secure Storage Needs to be a Low Risk Proposition to Justify Accruing the Capture, Processing, and Transportation Expenses
- Moving CO_2 from a Plant to Low Risk Secure Storage Sites is Also Expensive

Question: How Does One Balance the Risks of Nearby, but Higher Risk, Storage Sites with Expensive Pipelines to Low Risk Secure Site

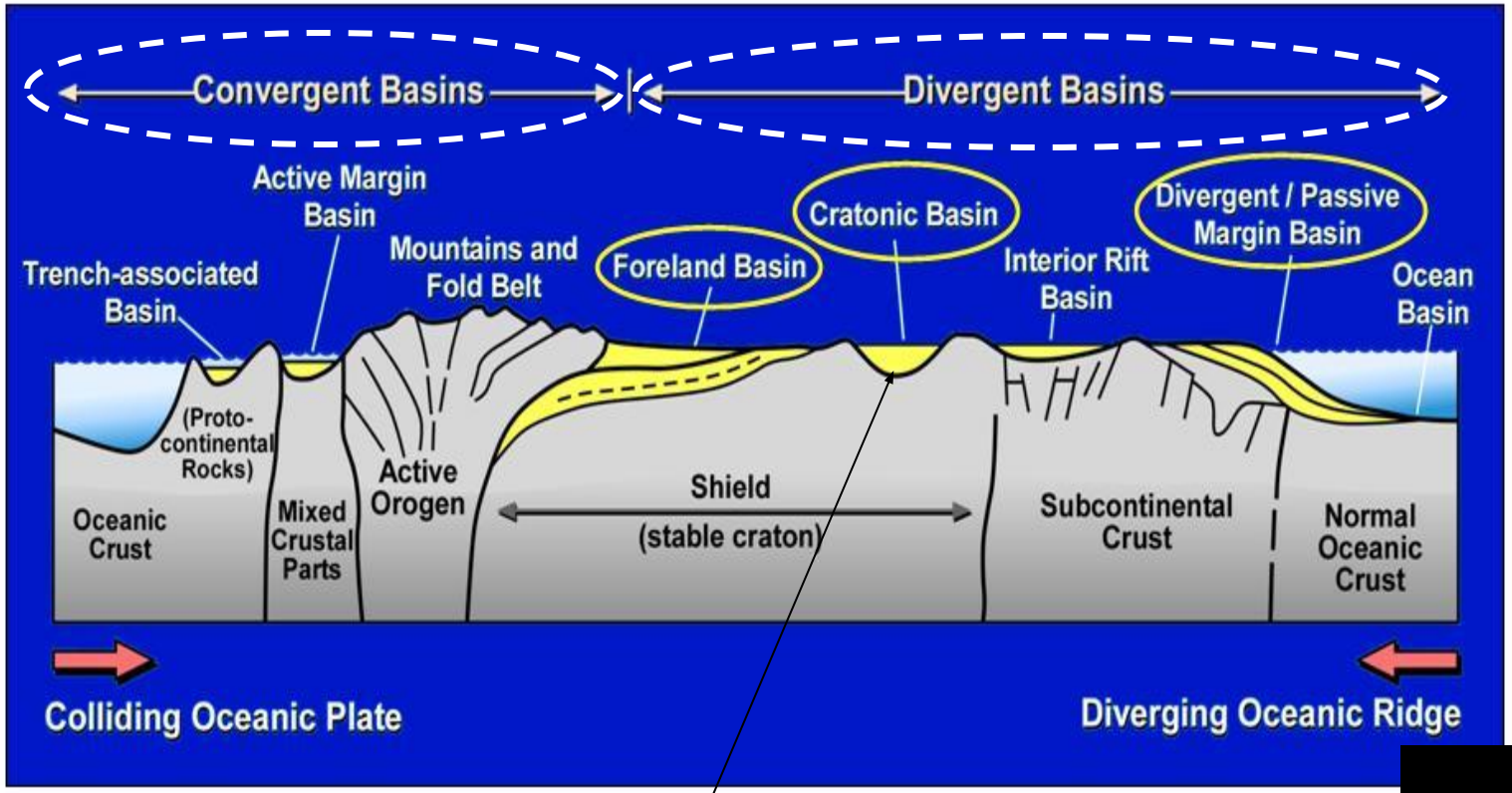


Secure Sites for CCS are Not Ubiquitous

- Many folks have worried about leaky wellbores *(industry fixes these when encountered)*
- A few studies have tried to categorize leaky geologies

The Following Slides are from a Report Attempting to Rate Subsurface Basins for Suitable Storage Site

Cross Sectional Representation of Various Types of Sedimentary Basins



Usually Evaporite Capped*

Source: Hitchon et a

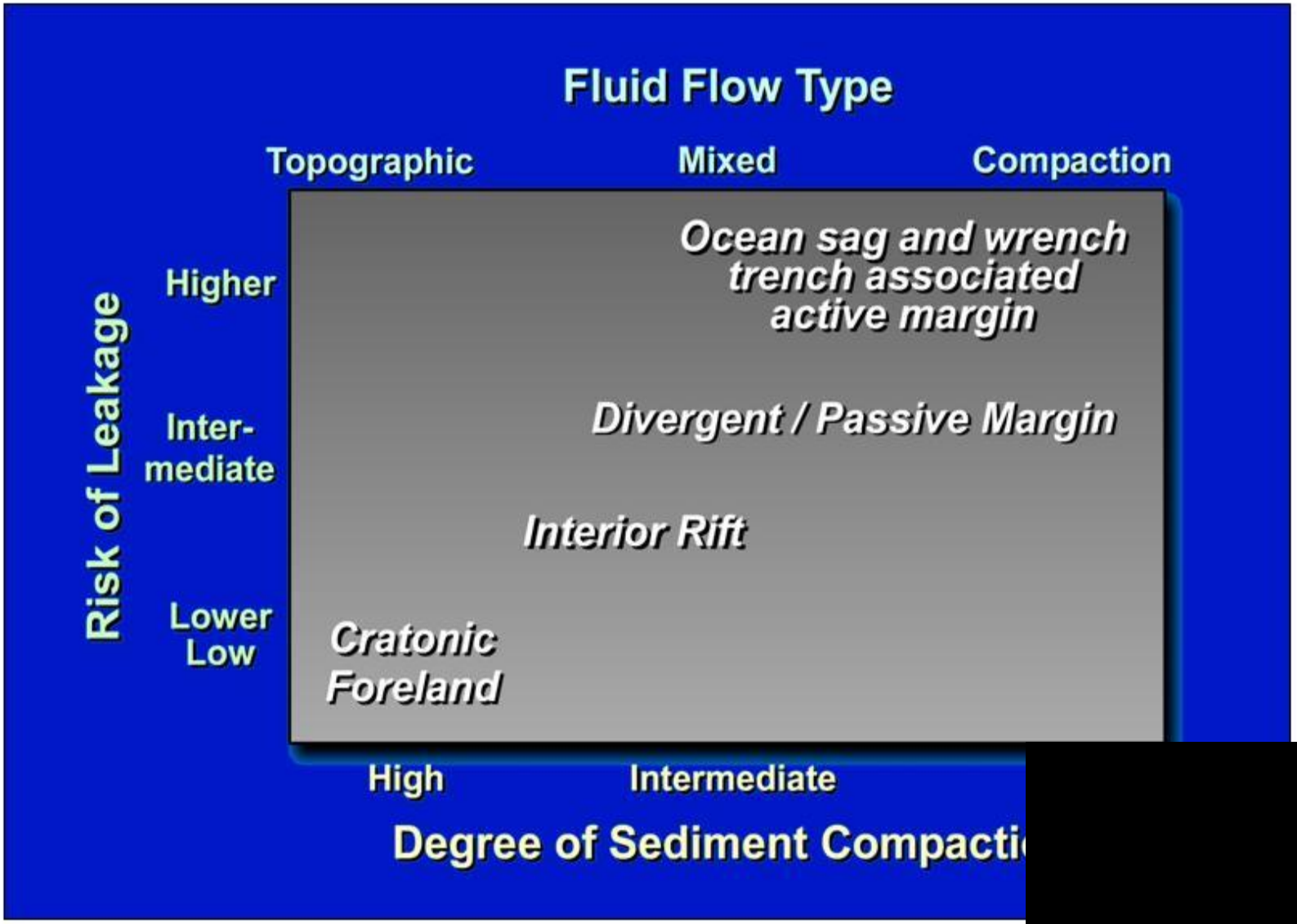
* Evaporites such as Salt (NaCl) and Anhydrites ($CaSO_4$) at >2500' Depth are Ductile and Provide Excellent Capping Seals

Ref: Hitchon et al, Dynamic basin analysis: an integrated approach with large data bases, Geological Society, London, Special Publications 1987, 34:31-44;

Hitchon et al, The role of hydrogeological and geochemical trapping in sedimentary basins for secure geological storage of carbon dioxide, Geological Society, London, Special Publications 2004, 233:129-145;

Hitchon B, Gunter WD, Gentzis T, Bailey RT (1999), "Sedimentary basins and

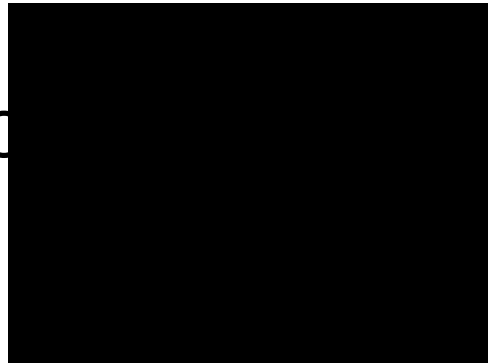
Risk of Leakage in Sedimentary Basins



“Macro” Site Risks for Storage

Critical Subsurface Storage Consideratons to Evaluate and Quantify

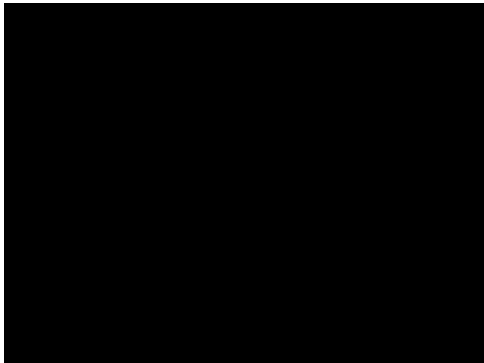
1. Pressure Management
2. Reservoir Seal Maintenance
3. Wellbore Integrity
4. Challenges in Determining Lateral Continuity of Reservoirs
5. Horizontal Drilling and Transmissive Natural Fracture Lessons
6. Today's Seismicity Lessons
7. Strike-Slip Faulting/Lineaments
8. Non-technical Factors Important for CC



It is Not all Study, Study, Study and Get Us Nowhere…

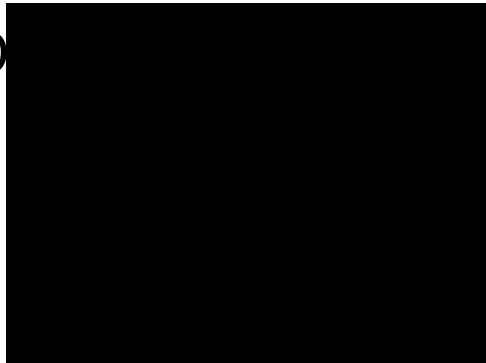
Fortunately, there is Good News

We have some case histories to rely upon so let's get moving



But…How Dangerous is it to Rely on Small Volume Injection Site Analogs?

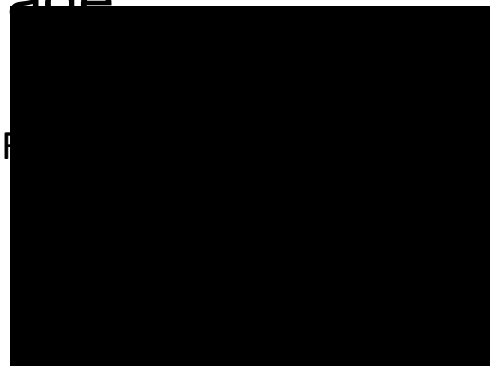
- Lots of excellent USDOE research has evaluated small volume CCS sites in many parts of the country
- The fast moving and very recent horizontal well experience of the oil and gas industry is demonstrating that the large volumes of water production and injection without fluid removal are, in several subsurface conditions, creating seismicity and seal issues
- The large expenses of CO_2 capture and processing for large volumes of CO_2 injection need more confidence than small volume injection pilots provide
- Where will the Insurance Companies Land on D
  Formation CCS?



So Where Do We See Higher Volume Secure Storage?

• Natural Gas Storage (Buoyant Fluid)	✔ Intermittent (Some Failures)
• National Oil Repositories (Strategic Petroleum Reserve)	✔ Salt Domes (Moderate Volumes – No Failures)
• Water Floods (Density Neutral)	✔ Long History but Density Neutral Injectant
• CO_2 Floods (Buoyant Fluid)	✔ 50-year History and Large Volumes of Storage*

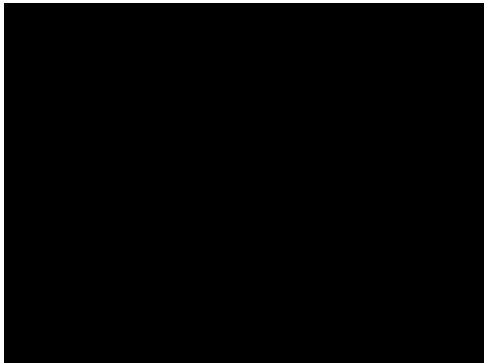
* Our Closest Thing to Secure Storage Sites with Buoyant F
Large Volume Analog



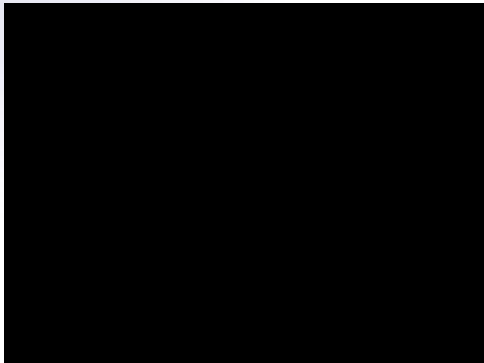
Demonstrated Secure Storage and Intra-cratonic Basins

(North America Specific)

- Permian Basin
- Alberta Basin
- Rockies Intermontane Basins
- Williston Basin
- Michigan Basin



IV. EOR “Dialing In” Low Carbon Oil

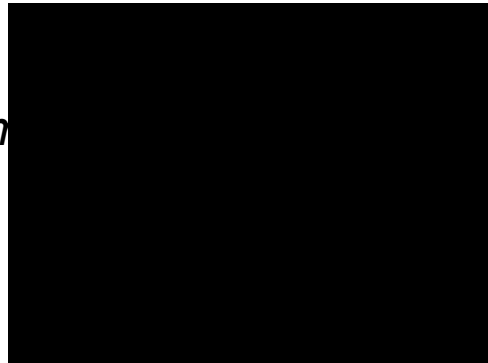


There is Still Pushback on CO_2 EOR with Storage

- "It Just Makes More Oil!"

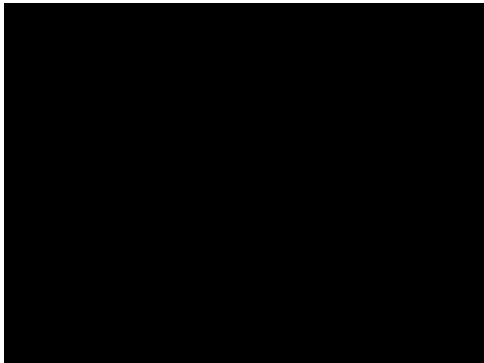
  But…..
- Has Proven Long Term and Secure Storage
- Long Standing Regulatory Regime is in Place now with Augmented SubPart RR* *(Mike Godec will be Addressing)*
- Unlike CCS Deep Saline Projects, EOR Balances Volumes In and Out of the Reservoir
- Insurance Companies Considerations – They Like Proven Track Records

* *For More Precise Documentation of CO_2 Volum*
Injected, Produced, and Recycled

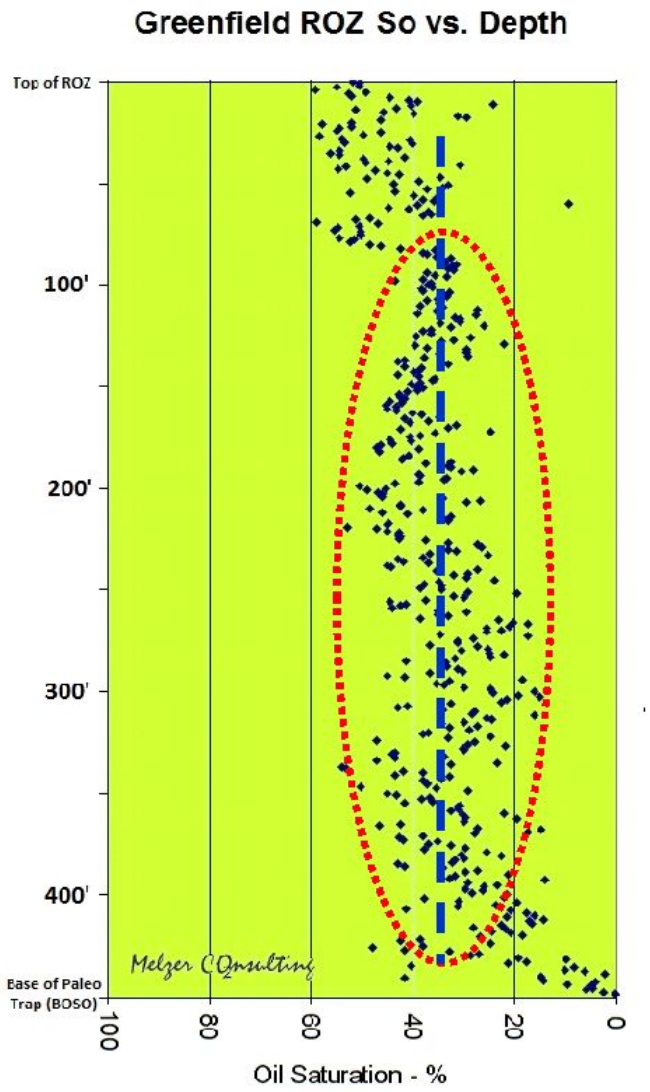


Can We Reduce Emissions of CO_2 While Making EOR Oil?

- Data Base of Life Cycle Assessments (LCA) on CO_2 EOR Oil *(Nick Will be Addressing)*
  - *When Only Oil Revenues Drove Success of EOR, CO_2 Purchases (and Reservoir Retained CO_2) has to be Minimized*
  - *Value of Storing CO_2 can be a Game Changer*
- Can We Design an EOR Project to Make a Carbon Neutral Barrel?



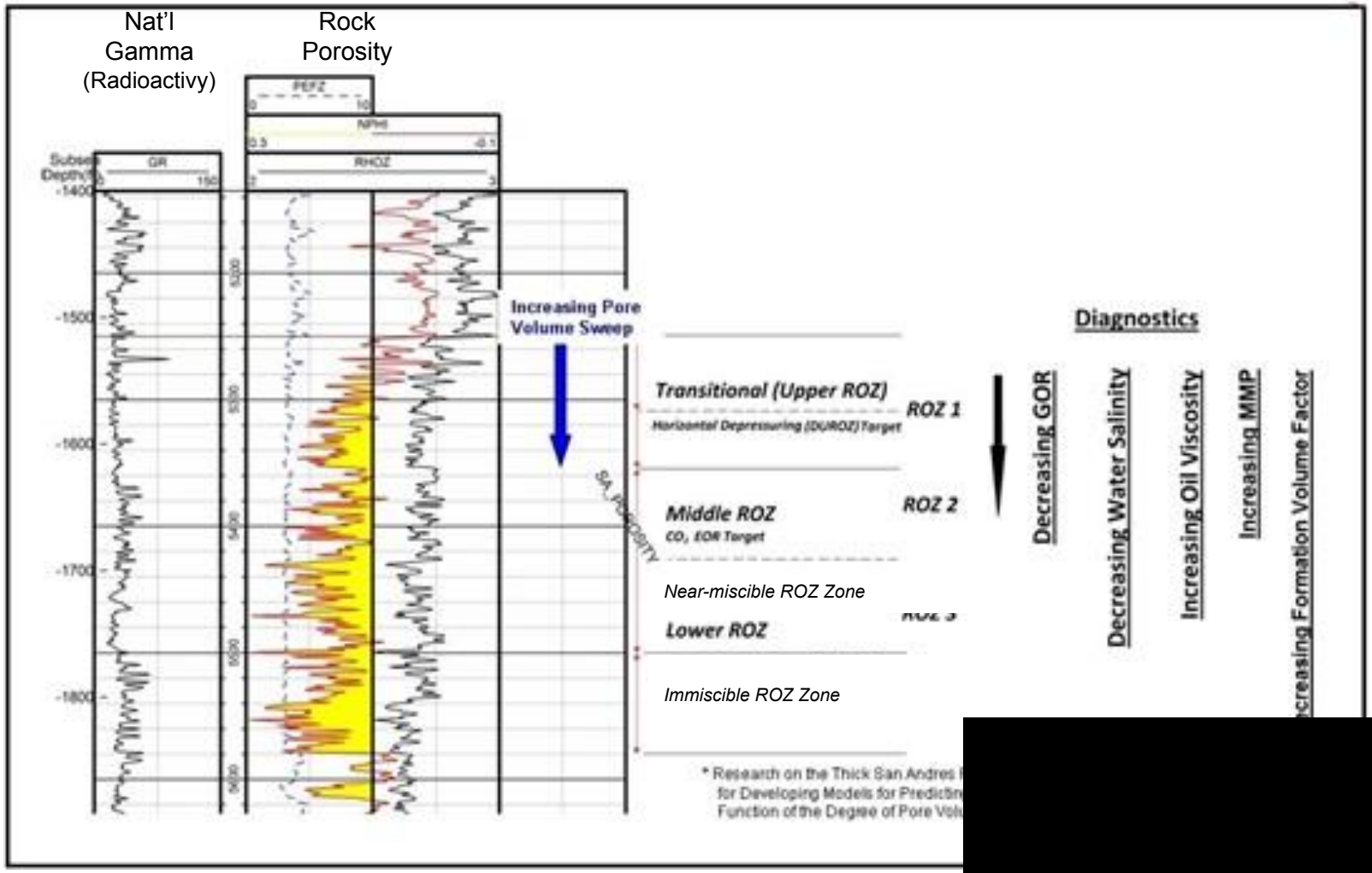
“Dialing in” Low Carbon Oil



How Deep to Flood?

Net Utilization* & Storage Factors

6-10 10-18 18-25



* Amount of New CO_2 required to produce a bbl of oil (mcf/bbl)

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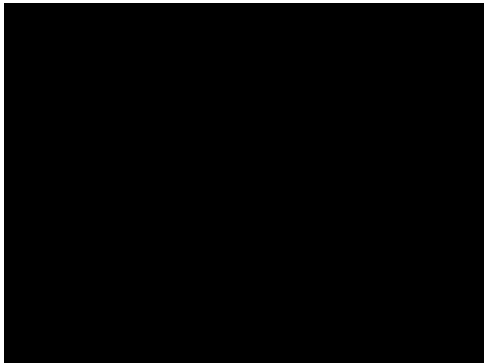
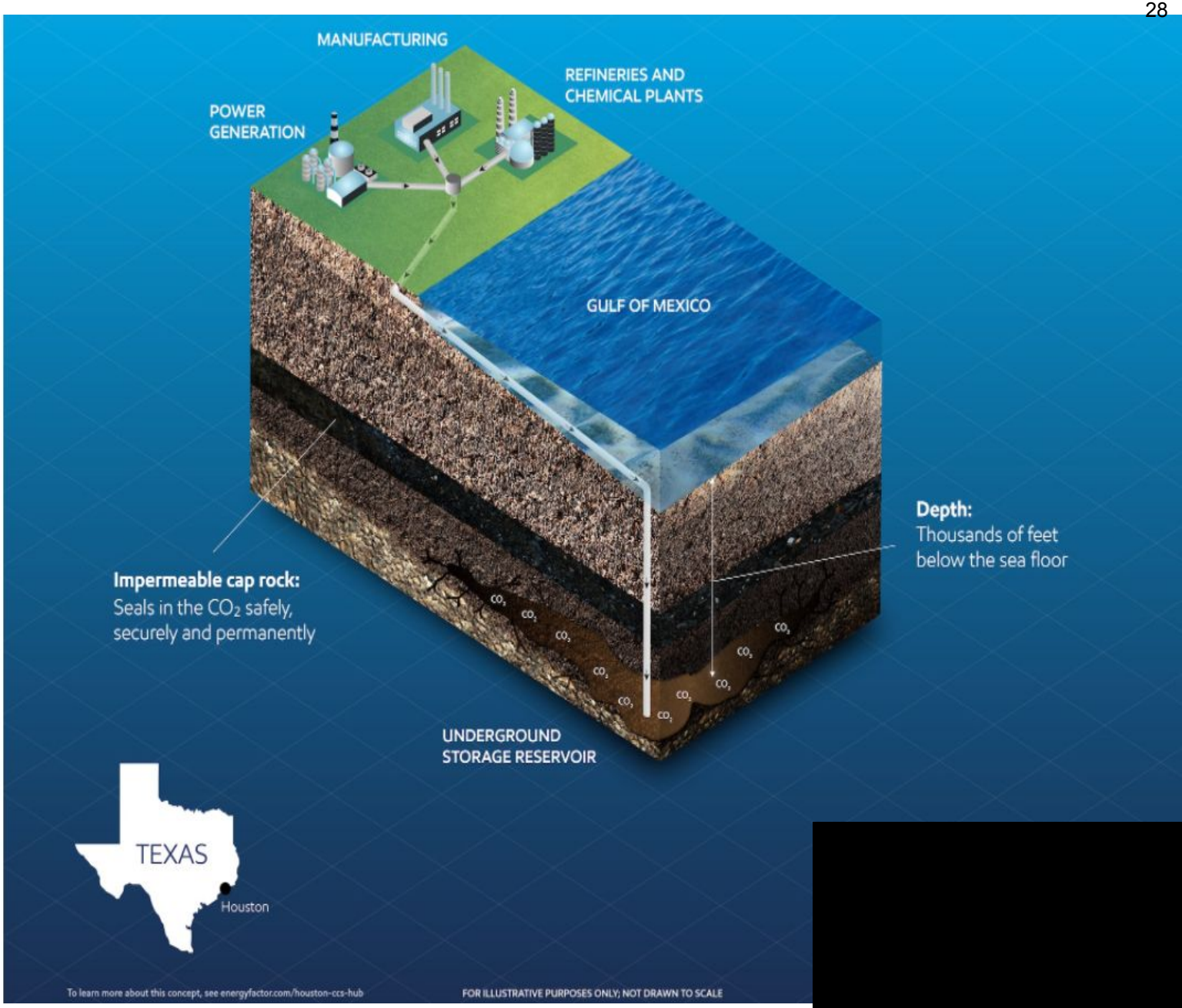
V. The Volumetrics and $ Involved: The Best Sites First



Exxon's Proposed Gulf Coast Projects

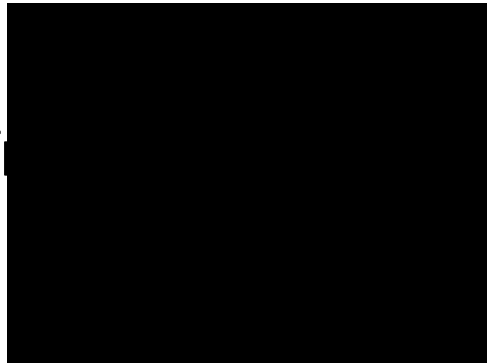


CO_2 Volumes Involved

- April 19, 2021 (Reuters) - Exxon Mobil (XOM.N) recently floated a proposal for a public-private carbon storage project that would collect planet-warming carbon dioxide emissions from U.S. petrochemical plants and bury them in deep under the Gulf of Mexico.
- Exxon wants to sequester **up to 100 million metric tons of CO_2 per year*** under Gulf of Mexico waters
- The plan would require **"$100 billion or more"** from companies and government agencies to store 50 million metric tons** of CO_2 by 2030, with capacity potentially doubling by 2040, Joe Blommaert, president of Exxon's Low Carbon Solutions business, said in an interview.

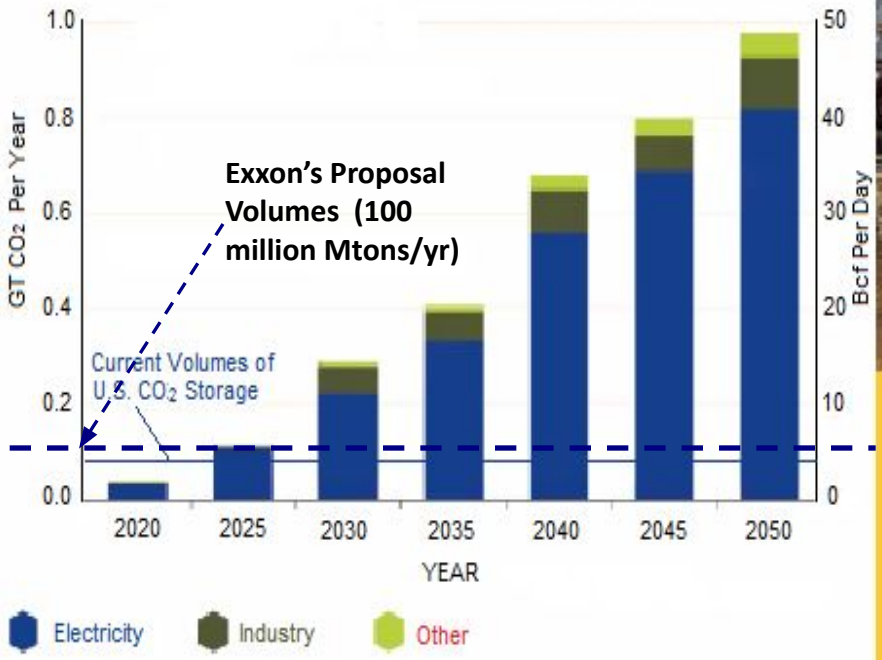
* Equivalent to ~5 bcf

** Equivalent to ~1 tcf



Deploy carbon capture, utilization and storage at scale

CO_2 Emissions Captured by CCS from all US Energy



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A US net-zero CO_2 energy system by 2050

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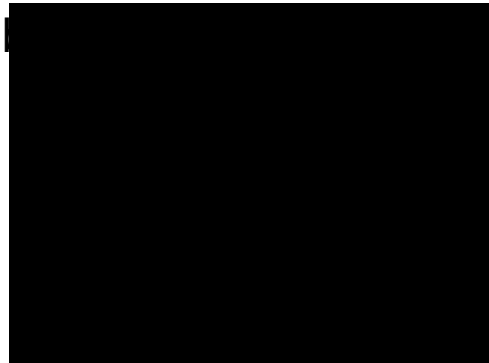
- Utilization of captured CO_2 is imp permanent (or near-permanent) st

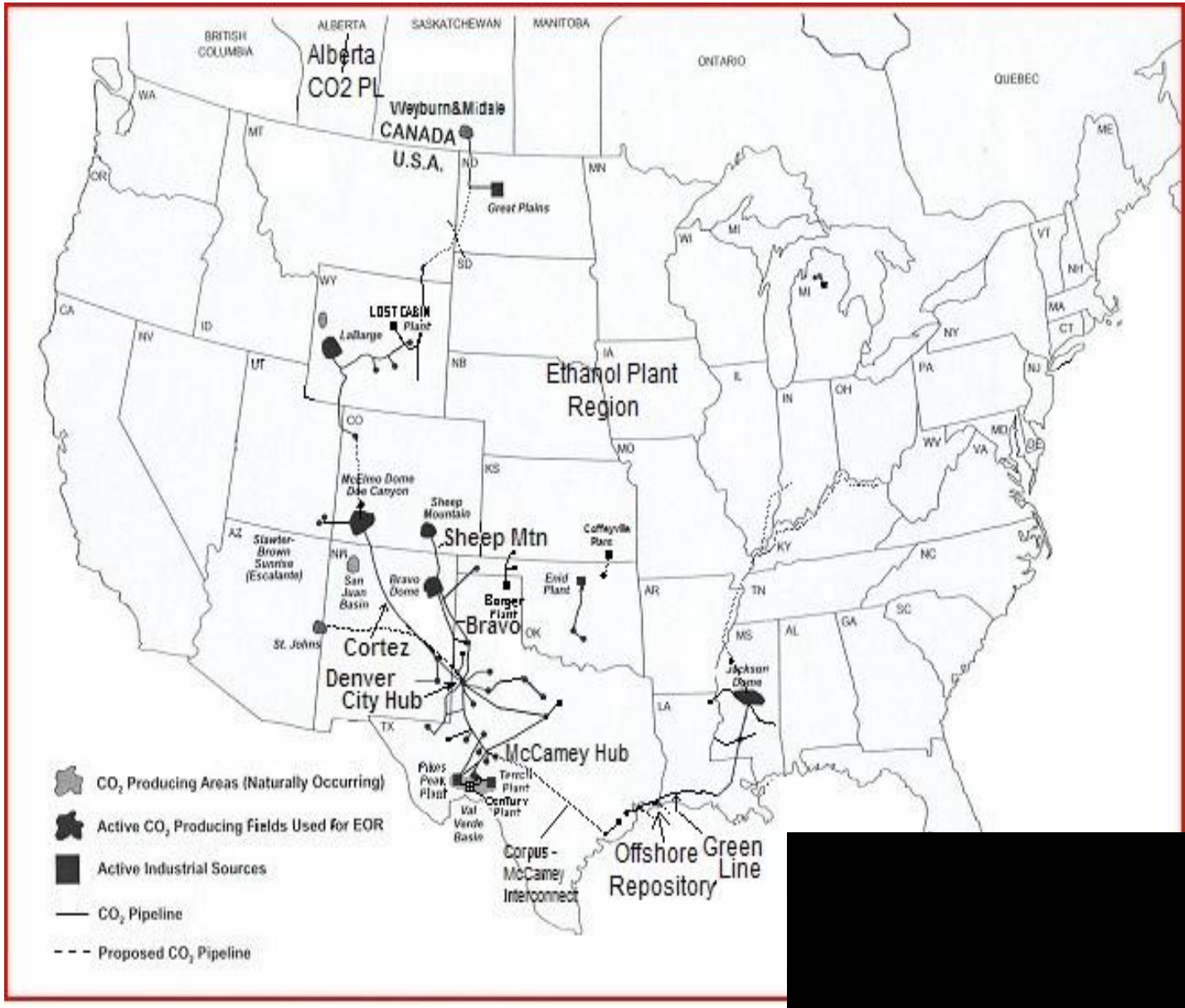
First Mover Projects: Fluid Withdrawal History/Strategies

- Shell's US Forecast Suggests ~50 bcfpd (1 gigaton/yr) of injection / storage required by 2050
- To scope the numbers involved:
  - US removes and sells ~10 million barrels of oil per day (3.65 billion bopy)
  - Subsurface reservoir 'voidage' is equivalent to ~500 million metric tons/yr
  - One-half of a gigaton/yr reservoir space is being created for CO_2

Question: Should early implemented CO_2 pipelines target secure sites and be deployed where large reservoir voidage is present or



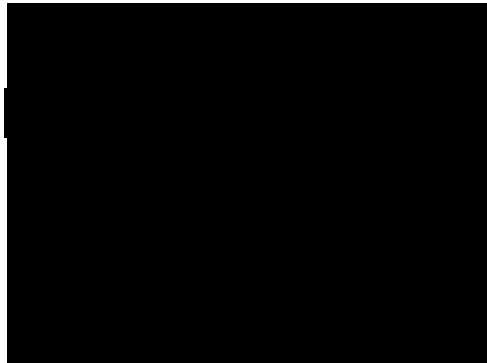
The Existing & Selected Proposed CO_2 Pipelines



VI. Summary

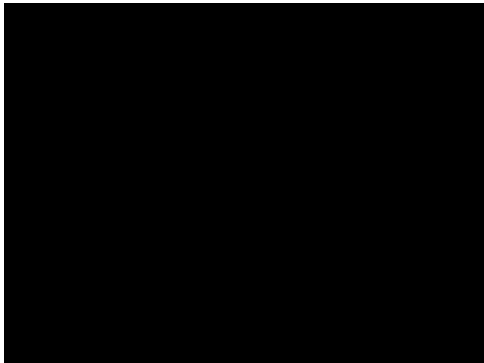
Summary (1)

- The developed, industrial world needs CCS (where energy reliability is fundamental to the economies)
- CCS can be done very successfully in appropriately screened sites
- Storage risks are many and many sites will require exclusion – pressure will be on the regulators
- Upfront Investment $ are immense and confirmation of low risk, secure sites is a priority prior to project $ commitments
- Fortunately, proven secure sites are avai



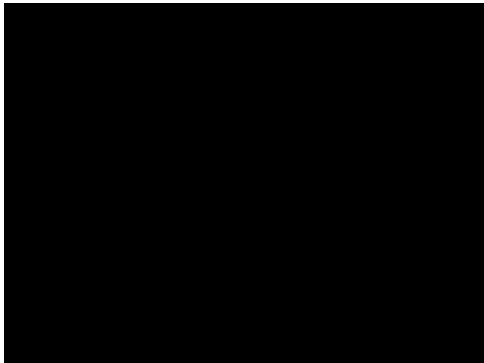
Summary (2)

- Current US secure storage in CO_2 EOR is 50-60 million tons/yr but will require 15-20x scale-up
- The existing network of CO_2 pipelines can be utilized to lower overall investment costs
- However, long distance, large diameter CO_2 pipelines will be required to access the additionally required secure storage locations
- Secure CO_2 storage is proven and expansion to the volumes needed is feasible



Summary (3)

- Existing, well designed and executed CO_2 EOR projects create a low carbon oil
- When incremental value for storage is considered, newly designed CO_2 EOR projects can produce a very low carbon or even carbon neutral oil
- Retraining large groups of geotechnical professionals for secure CO_2 storage is a necessity
- The existing oil industry professionals need to be central figures in the new CO_2 storage industry



Thank you

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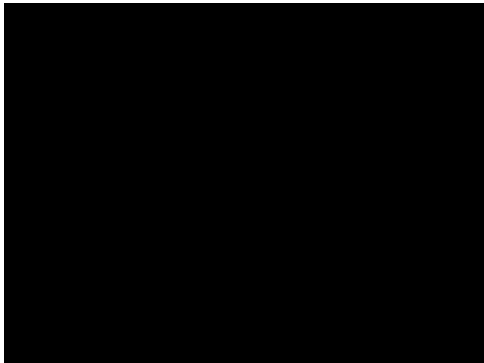

2021 CO_2 Conference

- 22nd Annual !!: Dec 6-9, 2021
- Midland, Texas – Bush Convention Center
- Field Trip to CCUS / CO_2 EOR Project – Host: Oxy Permian at West Seminole Field, 60 minutes north of Midland - Monday, Dec 6th
- Carbon Management Workshop – Tuesday and Wednesday, Dec 7 & 8
- CO_2 EOR and CCUS Case Histories, Thursday Dec 9th