2021 CO_2 EOR Carbon Management Workshop Program Recap - ***19th year***

Michael E. Moore Workshop Program Director

EWSA - USEA
Midland, Texas December 9, 2021

The 2021 Conference Committee Wishes to Express a Heartfelt thank you to all the Sponsors for the 27th Annual CO_2 Conference

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Supporting Sponsors – CO_2 EOR Carbon Management Workshop

Opening Day Program (Tuesday Dec 7th): CO2 EOR Carbon Management Workshop

8:00-5:45 - The Very Latest Policy, Regulatory, and Market Developments

7:15 -- 8:00	Registration / Check-in / Refreshments	
8:00 -- 8:15	EOR Carbon Management Workshop Opening Remarks	Michael Moore EWSA and Steve Melzer of API A & Melzer Consulting
8:15 -- 8:45	CO2 Storage and Incidental Carbon Neutral Oil the new "Prize"	Mike Godec, SVP Advanced Resources International (ARI)
8:45 - 9:15	Global CCUS Status and the 2021 Gobal CCUS Report	Christina Staib Global CCS Institute Houston
9:15 - 9:30	Break	
9:30 - 11:00	SSEB States CCUS and UH CCME CCUS Alliance	Ken Nemeth Executive Director SSEB
9:30 - 11:00	SSEB States CCUS and UH CCME CCUS Alliance	Charles McConnell U of H Executive Director CCME
11:00 - 12:00	Infrastructure Bill-/Reconcilliation Bill, EPA and CCUS	Fred Eames Partner - Hunton Andrews-Kurth
11:00 - 12:00	45Q Tax Credit Opportunities now and what could be ahead	David Lowman Partner - Hunton Andrew-Kurth
12:00-1:00	Buffet Lunch on Site	
	Keynote Speaker Anthony Ashley VP Energy Transition Ventures Kinder Morgan Inc	
1:00 - 1:30	Low Carbon EOR Oil and the LCA	Nick Azzolina EERC
1:30 - 2:00	CCUS and Clean Hydrogen Policy and Developments	Shannon Angielski Excutive Director CURC & Mike Wiener Clean Hydrogen Future Coalition
2:00 - 2:30	Full CCUS Technology Deployment	Ricky Sakai/Tiffany Wu, Mitsubishi Heavy Industries
2:30 - 3:30	State of Wyoming Energy Stategies and CCUS/CCS	Dr. Glen Murrell Executive Director Wyoming Energy Authority
3:30 - 4:00	Break Networking	
4:00 - 5:00	North Dakota Clusters & Hubs CO2, H2, Carbon Credits and Technology	John Harju, Kevin Connors, John Hamlin EERC
5:00 - 6:00	Low Carbon EOR Oil-Carbon Credits from CCUS, Emissions & Carbon Markets	John McDougal Element Markets
5:00 - 6:00	Markets Insights and Wrap Up	Mike Moore EWSA/USEA Steve Mezler APTA
6:00	Adjourn	

6:00 - 7:45pm Reception there: Presentation at 6:00 pm by Rusty Braziel, RBN Energy - Title: "I can't get no Sequestration: Ensuring CO2 EOR's Role in Energy Decarbonization"

Wednesday Dec 8th 8:00-11:45 - CCS & CCUS Advances and Issues

7:15 -- 8:00	Registration / Check-in / Refreshments	
8:00 – 8:30	Opening Remarks	Michael Moore EWSA & CM Workshop Director
8:30 -- 9:45	CO2 Security, Integrity, and Assurance	Panel of Speakers: Mike Moore Moderator Fred Eames HAK, Jessica Raines Baker-Hughes
9:45 – 10:15	Networking Break	
10:15 - 11:45	CO2 Storage Regulatory & Policy Achievements and Issues	Panel of Speakers, Mike Moore Moderator Marcella Burke King & Spalding, Shari Ring CADMUS

CO2CMW Sessions Concluded

Pursuing Lower Carbon Intensity Hydrocarbon Supplies

Prepared for:
Carbon Capture Utilization & Storage Workshop
Session I: State & Federal Policy Updates, Regulatory, and Market Developments

Midland 2021 CO_2 Conference

Prepared by:
Vello A. Kuuskraa, President

Presented by:
Michael L. Godec, Vice President
Advanced Resources International, Inc.
Arlington, VA USA

December 7, 2021
Midland, TX

Carbon Intensity of Alternative Sources of Oil Supply

The presentation will examine the Carbon Intensity of storing CO_2 and producing domestic oil from three distinct hydrocarbon settings.

Source of Carbon Emissions	Storing CO_2 in Hydrocarbon Basins (g CO_2/MJ)	Carbon Intensity of Other Oil Sources	
		Conventional Domestic Oil	Imported Oil
		(g CO_2/MJ)	(g CO_2/MJ)
Conventional Production (Extraction, Transport, Refining)	11	11	12
EOR Operations	3		
Combustion	73	73	73
CO_2 Storage	(**)		
Total Carbon Intensity	**	**84**	**85**

**To be addressed by this presentation.

Displacing Imports of Higher Carbon Intensity Oil

Life-cycle analysis (LCA) shows that the carbon intensity of one barrel of oil produced by injection of CO_2 is 87 g CO_2/MJ, consisting of:

- 11 g CO_2/MJ for oil extraction, refining and transportation(1),
- 3 g CO_2/MJ for EOR(2), and
- 73 g CO_2/MJ when consumed.

However, a significant volume of CO_2 can be stored for every barrel of oil produced with injection and storage of CO_2 in hydrocarbon formations, enabling the production of low (and even negative) carbon intensity domestic oil.

Imported oil has a positive carbon intensity of 85 g CO_2/MJ.

1. Masnadi, M.S, et al. "Global carbon intensity of crude oil production." Science Magazine, Vol. 361, Issue 6405, pp. 851-853. August 2018.
2. Godec, M., Carpenter, S., and Coddington, K., 2016. Evaluation of Technology and Policy Issues Associated with the Storage of Carbon Dioxide via Enhanced Oil Recovery in Determining the Potential for Carbon Negative Oil, prepared for GHGT-13, 14-18 November 2016, Lausanne, Switzerland, Energy Procedia 114 (2017) 6563-6578.

Producing Low Carbon Intensity Oil

Over 40 billion metric tons (Gt) of CO_2 could be stored with enhanced oil recovery technology in a variety of domestic hydrocarbon settings.

	Hydrocarbon Settings	CO_2/Oil Ratio (mt/bbl)	Carbon Intensity (g/MJ)		
			Total	Storage	Net
1	Three Shale Oil Formations (1)	0.67	87	(109)	(22)
2	Conventional Onshore Oil Fields (2)	0.48	87	(78)	9
3	Residual Oil Zones (3)	0.46	87	(75)	12

All three settings can provide low (some even negative) carbon intensity domestic oil when evaluated using Life Cycle Analysis (LCA).

1. "The "Increasing CO2 Storage Options with Injection of CO2 in Shales," USEA Webinar presented by Vello Kuuskraa (ARI) and Graeme Finley, (EORI), November 16, 2021.
2. "Improving Domestic Energy Security and Lowering CO2 Emissions with "Next Generation" CO2-Enhanced Oil Recovery (CO2-EOR)", DOE/NETL-2011/1504, July 2011, prepared by Advanced Resources International, Inc., updated in 2019 by Advanced Resources International, Inc.
3. A series of reports addressing the "San Andres ROZ Fairway Resources of the Permian Basin" prepared by Advanced Resources International for U.S. DOE, 2016-2018.

GLOBAL STATUS OF CCS 2021

Global CCS Institute

Midland CO_2 Conference
December 7, 2021

THE GLOBAL CCS INSTITUTE

- International climate change think tank
- Not-for-profit entity limited by guarantee, incorporated in Australia
- HQ in Melbourne
- Offices in Washington D.C., Houston, London, Brussels, Abu Dhabi, Beijing, and Tokyo
- Member-led organization
- Diverse international membership consists of governments, global corporations, small companies, and NGOs
- Specialist expertise covers the complete CCS/CCUS chain

OUR VISION
CCS is an integral part of a low emission future

OUR MISSION
To accelerate the deployment and commercial viability of CCS globally

CCS: REACHING NET-ZERO AND DRIVING THE LOW-CARBON ECONOMY

- Achieve industrial decarbonization including deep decarbonization in hard-to-abate industry
- Enable the production of low-carbon hydrogen at scale
- Provide low carbon dispatchable power
- Deliver negative emissions

THE GLOBAL STATUS OF CCS 2021

THE MOMENTUM AROUND CCS CONTINUES

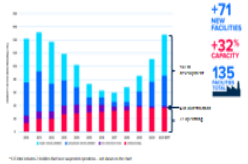
+71 NEW FACILITIES

+32% CAPACITY

135 FACILITIES TOTAL

THE GLOBAL STATUS OF CCS 2021

FOUR YEARS OF GROWTH IN THE PROJECT PIPELINE



71 NEW FACILITIES ADDED IN 2021

- 41 new commercial facilities added in North America (31 of these part of the Summit Network), 25 in Europe and 5 across the rest of the world
- First commercial facilities in Belgium, Denmark, Hungary, Indonesia, Italy, Malaysia and Sweden
- First CCS applications in LNG liquefaction
- First commercial DACCS project in Europe
- First commercial cement CCS facility under construction
- Several power CCS projects around the world

DRIVERS OF CCS MOMENTUM IN 2021

- Strengthening policy support for CCS
- Blue Hydrogen Projects
- Net Zero Commitments from countries and companies
- Technology-based Carbon Removal
- Rise of CCS Networks
- Emergence of Strategic Business Partnerships

CCS FACILITIES

OPERATIONAL AND UNDER DEVELOPMENT

CCS FACILITIES AROUND THE WORLD

	OPERATIONS	IN DEVELOPMENT	SUSPENDED	TOTAL
North America	16	60	2	78
China	3	3	-	6
Europe	3	35	-	38
Gulf Cooperation Council	3	1	-	4
Rest of World*	2	7	-	9
Total	27	106	2	135

INCREASING DIVERSITY OF APPLICATIONS

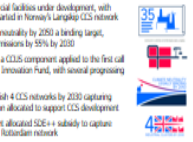
NORTH AMERICA

- More than 40 facilities added to the Institute database in 2021
- In February 2021, the US rejoined the Paris Agreement
- The US Energy Act of 2020 passed, which authorized more than $8 billion for CCS research, development and demonstration for FY 21 – FY 25
- Major bills introduced in the US Congress during 2021 to augment 45Q tax credits
- Canada's Budget 2021 proposed an investment tax credit for CCS projects. Proposed Clean Fuel Regulations include use of CCS to generate credits
- Biorefinery networks and low-carbon LNG with CCS emerging

+40

EUROPE

- More than 30 commercial facilities under development, with construction having started in Norway's Langskip CCS network
- The EU made climate neutrality by 2050 a binding target, along with reducing emissions by 55% by 2030
- Over 60 projects with a CCUS component applied to the first call of the EU's €20 billion Innovation Fund, with several progressing to the final round
- The UK aims to establish 4 CCS networks by 2030 capturing 10 mtpa, with £1 billion allocated to support CCS development
- The Dutch Government allocated SDE++ subsidy to capture facilities in the Port of Rotterdam network



ASIA PACIFIC

- 5 new facilities in APAC added to the database
- First commercial CCS projects announced in Indonesia and Malaysia
- China launched its Emission Trading Scheme, covering >2000 power plants. CCS included in China's 5-year plan for the first time
- Australia is including CCS in its Emissions Reduction Fund and allocated $300 million in funding for CCS projects and networks
- Japan is pursuing blue hydrogen opportunities and driving transnational cooperation in CCS

GCC STATES

- 3 CCS facilities in operation in the GCC States, capturing 3.7 Mtpa of CO_2, about 10% of global capture capacity in operation
- Qatar Ras Laffan and UAE Al Reyadah facilities are developing expansion plans
- Bahrain, Qatar, Saudi Arabia and UAE include CCS in their NDCs* under the Paris Agreement
- Power generation and blue hydrogen are expected to emerge as new CCS drivers in the region
- The Global CCS Institute is opening its inaugural GCC office in Abu Dhabi

CCS: VITAL TO NET-ZERO

- Despite progress in 2021, to achieve net zero emissions, CCS capacity must increase by 100-fold by 2050
- Between US$655 - $1,280 billion in capital investment is needed in the next three decades
- Stronger policy to incentivize rapid CCS investment is overdue

STRONG POLICY ACTION NEEDED

- Define the role of CCS in meeting national emissions reduction targets and communicate this to industry and the public.
- Create a long-term, high value on the storage of CO_2.
- Support the identification and appraisal of geological storage resources.
- Develop specific CCS laws and regulations.
- Ensure emissions abatement policies are inclusive of all options (including CCS).
- Identify opportunities for CCS networks and facilitate their establishment.
- Provide capital grants, low-cost finance and/or guarantees to reduce the cost of capital for CCS investments.

THANK YOU

Download our *Global Status of CCS 2021 Report* at www.globalccsinstitute.com

Follow us on social media: @GlobalCCSI

Further questions? Reach out:
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or
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CCUS Commercialization: Leadership in the South

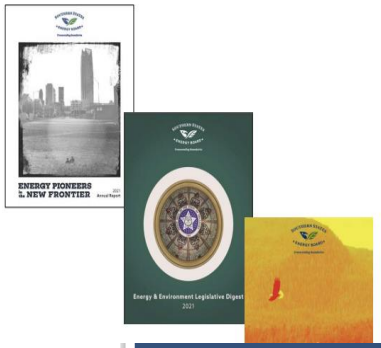
Jointly Presented by:

Kenneth J. Nemeth, Southern States Energy Board

Charles McConnell, University of Houston, Center for Carbon Management in Energy

New Publications

- **Annual Report**
- **Energy & Environment Legislative Digest**
  - Over 540 energy & environmental measures
  - Trends
    - Energy discrimination
    - Broadband deployment
    - Electric vehicle infrastructure
    - Renewable energy
- **Fossil Energy & Carbon**



FECM State-level Legislative Trends

- CCUS development and deployment trends: funding carbon capture studies and offering tax incentives for technology deployment.
- Advanced Recycling continues to trend in our member states and legislatures across the nation.
- Kansas and Montana join the ranks of nearly every SSEB member with the passage of their critical infrastructure trespass protection laws.
- Twelve states, six of which are SSEB members, passed

Monitoring Federal Action

- White House - Executive Orders (EO) and Scientific Integrity Presidential Memorandum
- U.S. Department of State & White House Executive Offices– "The Long-Term Strategy of the United States: Pathways to Net-Zero Greenhouse Gas Emissions by 2050" (Nov. 2021) https://www.whitehouse.gov/wp-content/uploads/2021/10/US-Long-Term-Strategy.pdf
- Congress - Infrastructure Bill – CCS (including CarbonSAFE expansion) and H_2 hubs; Build Back Better Act; and more!
- Office of Science and Technology Policy's (OSTP) New Energy Division
  - Dr. Sally Benson appointed new Deputy Director for Energy and Chief Strategist for the Energy Transition at OSTP (Nov. 2021)
- U.S. Department of Energy
  - Energy Earthshots (expecting 6-8 total), currently includes Hydrogen Shot, Long Duration Storage Shot, and Carbon Negative Shot
  - Carbon Dioxide Removal (CDR) Mission
  - CCS Centres of Excellence (US, UK, Canada, Indonesia, IEA GHG R&D Programme)
  - Incorporation of EO 14008 mandates

- EO 14007, President's Council of Advisors on Science and Technology (Jan. 2021)
- EO 14008, Tackling the Climate Crisis at Home and Abroad (Jan. 2021)
- EO 14027, Establishment of the Climate Change Support Office (May 2021)
- EO 14030, Climate-Related Financial Risk (May 2021)
- EO 14048, Continuance or Reestablishment of Certain Federal Advisory Committees and Amendments to Other Executive Orders (Sept. 2021)
- EO 14052, Implementation of the Infrastructure Investment and Jobs Act (Nov. 2021)

https://www.federalregister.gov/presidential-documents/executive-orders/joe-biden/2021

Transcending Boundaries

Carbon Management Program

Carbon Management Program Acknowledgements

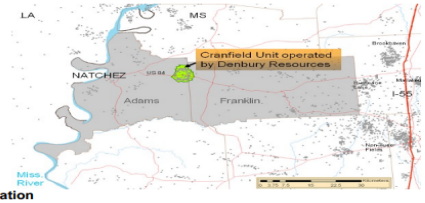
This presentation is based upon work supported by the Department of Energy and was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

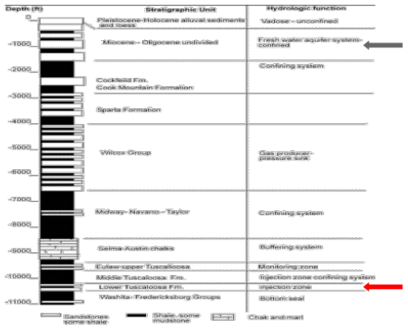
SECARB Phase II & Phase III Project Sites

#	Name/Description	Location	CO_2 Source	CO_2 Stored (metric tons)
1	Coal Seam Project	AL	Natural	1,000
2	Coal Seam Project	VA	Anthro-pogenic	1,000
3	Saline Stacked Storage	MS	Natural	500,000
4	Saline Storage	MS	Natural	3,000+

#	Name/Description	Location	CO_2 Source	CO_2 Stored (metric tons)
5	CO_2-EOR	MS	Natural	5,000,000+ (10MM injected)
6	Saline Storage	AL	Anthro-pogenic (from new CO_2 capture facility)	100,000+

SECARB Phase III Early Test





Location

- 15 miles east of Natchez, MS
- Oilfield discovered in 1940s and abandoned in 1960s
- Currently owned/operated by Denbury Onshore LLC
- CO_2-EOR injection since 2008, Natural CO_2, Jackson Dome

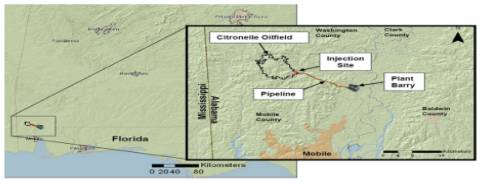
Geology

- Target Injection Zone: Lower Tuscaloosa Formation – saline reservoir at depth of >10,000 feet

SECARB to Petra Nova

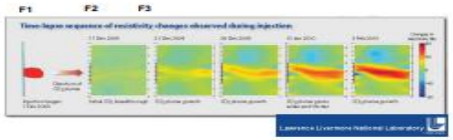
SECARB Phase III Anthropogenic Test

- Carbon capture from Plant Barry, 25MWe
- 12-mile CO_2 pipeline constructed by Denbury Resources
- CO_2 injection into ~9.400 ft. deep saline formation (Paluxy), Class V Experimental UIC Permit
- 114,000 metric tons injected
- Monitoring CO_2 during injection



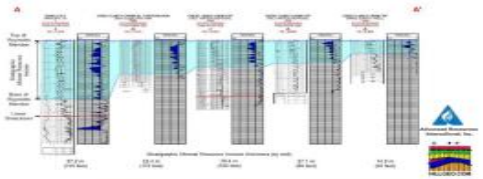
SECARB Firsts (selected)

- First RCSP in the field
- First RCSP to inject CO_2
- First RCSP to monitor a 1 million metric ton injection
- First deep and first U.S. use of electrical resistance tomography (ERT) in CO_2 setting
- First application of pressure surveillance in an above-zone monitoring interval
- Process-based soil gas monitoring method (also used at the Kerr farm in Canada)
- First U.S. and first onshore use of borehole gravity to quantify CO_2 displacing water
- World's first fully integrated CO_2 capture (amine), transportation, storage (saline) project utilizing anthropogenic CO_2 from a coal-fueled power plant



Arkansas CCUS Assessment

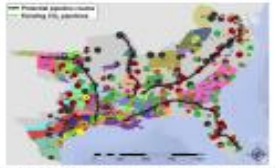
- Gov. Asa Hutchinson requested a robust assessment of CCUS opportunities in Arkansas.
- Results presented to Arkansas-based government officials and industry in April 2021 and to community stakeholders in June 2021.
- May provide a means for revitalization of southwest Arkansas.



SECARB-USA | Regional Initiatives Map

SECARB-USA

- Identify and address regional onshore storage and transport challenges facing commercial deployment of carbon dioxide (CO_2) capture, utilization, and storage (CCUS) technologies.
- The project team has evaluated the costs associated with site characterization and Class VI UIC permitting while identifying areas requiring additional characterization.
- Will continue to evaluate infrastructure buildout scenarios to better understand project costs and stakeholder engagement strategies.
- Continue to meet with stakeholders to discuss CCUS opportunities in the southeast and identify potential areas of collaboration.



Hypothetical pipeline routes connecting major point-source emitters to existing pipeline infrastructure.

Industry Partners

SECARB-USA

CCS Prospects in Georgia & Alabama

- Partnered with Southern Company and Advanced Resources International to drill two stratigraphic/characterization wells in the Valley and Ridge province of northern Georgia and north-central Alabama.
- An area of the region that has not experienced historical oil and gas exploration so there is limited existing data.
- Important to understanding CCUS commercialization opportunities in the region.
- Cassville Stratigraphic Test Well (Bartow Co., GA):
  - Total Depth of 6,030 ft reached on September 14, 2021
  - Collected open-hole geophysical data, formation microimager data, and sidewall core
- Westover Stratigraphic Test Well (Shelby Co., AL):
  - Total Depth of 6,000 ft reached on November 5, 2021
  - Collected open-hole geophysical data and formation microimager data.

Aerial photograph of the Cassville stratigraphic test well located in Bartow County, GA.

Webinar Series

- SSEB hosts a regular webinar series to discuss timely news related to energy and the environment.
- Almost 400 total attendees over 4 separate webinars.
- Over 100 individuals registered for the July 15, 2021, Regional Initiative Webinar
- 150 individuals registered for the August 25, 2021, SECARB-USA Webinar
- Effective means to generate interest in CCUS and the work of the Regional Initiatives while engaging with a diverse group of stakeholders.
- For more information and to view past webinars visit www.sseb.org/webinar-archive/

CarbonSAFE - Project ECO$_2$S Phase III (Mississippi)

- Establishing a regional storage complex for CO_2 from stationary sources.
- **Estimated storage capacity of almost 1 billion metric tons (P_{50})!**
- Three new characterization wells drilled and nearly 100 linear miles of 2D seismic acquired.
- Currently drafting EPA Underground Injection Control Class VI well permit.

Research Partners

Direct Air Capture of CO_2 (Alabama)

- Decreasing CO_2 capture costs through testing in integrated field units that produce a concentrated CO_2 stream of at least 95% purity.
- Completed engineering and design of test skid.
- Procuring materials required for test skid construction.

Synapse Build Labs

CO_2 Processing Skid

National Carbon Capture Center
https://www.nationalcarboncapturecenter.com

DAC RECOUP Stakeholder Network

- BP
- Clean Air Task Force
- Carbon Utilization Research Council
- Georgia Tech Agricultural Technology Research Institute
- Good People Brewing Company
- Marathon Petroleum
- Pilgrim's Pride
- Shell
- Southern Company Services
- Tennessee Valley Authority
- University of Georgia College of Engineering
- Virginia Center for Coal and Energy Research at Virginia Polytechnic Institute and State University

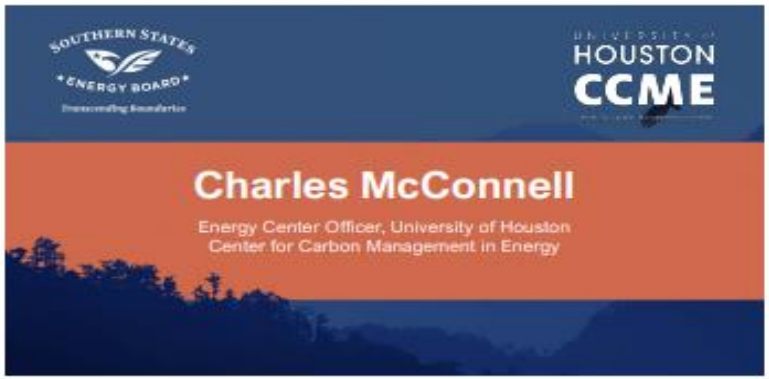
SECARB Offshore Partnership: Gulf of Mexico

- CO_2 storage and Enhanced Recovery Assessment for eastern GOM, including the analysis of existing and required legal and regulatory frameworks in anticipation of commercial deployment.
- The project team continues to assess CO_2 storage opportunities, evaluate infrastructure options, and identify risks associated with legacy infrastructure and geology.

Onshore CO_2 sources within 150 miles of the coast. Also shown are the Gulf Planning Areas and the SECARB-Offshore study area.

Modular units for subsea processing

Transcending Boundaries



CCUS Leadership Consortium

- Collaborative effort between the **Southern States Energy Board** and the **University of Houston's Center for Carbon Management in Energy**
- Mission: coordinate the capabilities and experience of industry, academia, and government to accelerate CCUS deployment in the Southern region, address key challenges, and promote regional technology transfer and knowledge dissemination – in response to NPC study
- Worked with subject matter experts to develop a roadmap that enumerates challenges to the commercial deployment of CCUS technologies and tasks to eliminate these challenges (finalized October 15, 2021)
- **The consortium is a mechanism for CCUS knowledge sharing**

"The solution is going to come from the private sector, and what government needs to do is create the framework within which the private sector can do what it does best, which is allocate capital and innovate..."

U.S. Climate Envoy John Kerry describing solutions to climate change at the Institute of International Finance's 2021 Washington Policy Summit

Transcending Boundaries

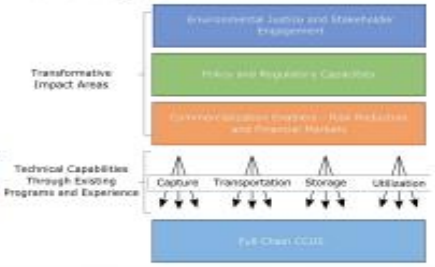
Leadership Consortium - Membership

Transcending Boundaries

Leadership Consortium - Timeline

Leadership Consortium - Challenges

- Subject matter experts identified a wide array of challenges to the commercialization of CCUS
- Many existing technical challenges are addressed by existing research programs
- A general need to focus on transformative challenges or those that apply to all aspects of the CCUS value chain
- **Required for far-reaching and just deployment of CCUS**



Leadership Consortium – Challenges to Be Addressed

- **Leverage the experience and membership of SSEB, the location and expertise of UH-CCME, and Consortium membership to address Transformative Impact Areas**
- **Social Enablers:** Stakeholder Engagement; Environmental Justice; Workforce and Community Transition
- **Policy and Regulatory Enablers:** Facility Permitting; Pipeline Permitting; Class VI Primacy; Site Stewardship
- **Commercialization Enablers – Risk Reduction and Financial Markets:** Storage Risks; Life-Cycle Assessment; Cost-Benefit; Standards, Certification, and Marketing

Leadership Consortium – Next Steps

- Continue to maintain the Consortium and host regular virtual and in-person meetings
- Identify opportunities to support industry activities
- Begin to carry out the activities outlined in the Roadmap
- **If you are interested in joining the Consortium or our activities, please reach out to SSEB and UH-CCME**

CCS in the Infrastructure and Reconciliation Bills

Fred Eames, Partner
January 25, 2021

HUNTON ANDREWS KURTH

1

Congress, the Administration, and CCS

- **Biden Administration**
  - Where's the "U"?
  - De-emphasize power sector
  - Emphasize DAC
- **Congress**
  - Clear evolution from a side issue to climate response essential pillar
  - Democratic climate hawks resisting environmental advocate pressure
  - Republicans highlighting efficient, secure, lower cost, lower emission, American energy

2

Energy Act of 2020

Key CCS Provisions

- Section 45Q Extension
- USE IT Act
- EFFECT Act

3

From Authorization to Funding

CCS-Related Energy Act of 2020 Funding in Bipartisan Infrastructure Bill

Program	U.S. Code Section	Common Reference	Energy Act of 2020	Infrastructure Bill H.R. 3684
Fossil Energy	[illegible]	[illegible]	[illegible]	[illegible]
Carbon Capture Technology Program	[illegible]	[illegible]	[illegible]	[illegible]
Carbon Storage Validation and Testing	[illegible]	[illegible]	[illegible]	[illegible]

Bipartisan Infrastructure Bill – H.R. 3684

Other Key CCS Provisions

- **Sec. 40302. Carbon Utilization Program.** [illegible]
- **Sec. 40303. Carbon Capture Technology Program.** [illegible]
- **Sec. 40304. Carbon Dioxide Transportation Infrastructure Finance and Innovation.** [illegible]
- **Sec. 40305. Carbon Storage Validation and Testing.** [illegible]
- **Sec. 40308. Carbon Removal.** [illegible]
- **Sec. 80402. Carbon Dioxide Capture Facilities.** [illegible]

Infrastructure Bill Implementation

Politico, December 6

- **DOE SEEKS CARBON MANAGEMENT INPUT:** The Energy Department is taking the first steps to implement initiatives of the recently enacted bipartisan infrastructure law, which includes more than $10 billion for DOE for carbon capture, direct air capture and industrial emission reduction. The Office of Fossil Energy and Carbon Management will publish a request for information today to gather insight from the public on carbon management technologies that are ready to be demonstrated.
- **The document seeks input** on potential carbon management demonstration and deployment projects, as well as point source carbon capture technologies and integrated projects; validation of carbon storage resources for commercial development; carbon dioxide pipeline infrastructure; direct air capture; opportunities for the recovery of critical minerals and to reclaim abandoned mine lands for clean energy. It also seeks information on the potential benefits to underserved communities related to the demonstration projects. Responses are due by Jan. 24, 2022.

USE IT Act

Two objectives

- **Accelerating permitting**
  - Adds "carbon capture" to covered projects for FAST Act permitting streamlining
  - Covered project - $200 million project size, subject to NEPA, not subject to other permitting streamlining
  - FAST Act – FPISC, lead agency to coordinate permitting across agencies, performance schedule, regular reporting
- **Promoting direct air capture**
  - Authorizes (but does not require) an EPA technology prize program within 1 year
  - >10,000 tpy capture
  - Applies to technology to be commercial "in the foreseeable future"
  - At least 1 coastal State and 1 rural State project
  - Authorizes a 9-member Direct Air Capture Technology Advisory Board
  - Report to Congress within 1 year on the risks and benefits of saline storage

4

EFFECT Act

Amends DOE's fossil fuel and CCUS RD&D programs to modernize the authority, broaden the program purposes, increase attention on CCUS for natural gas, focus spending on large-scale pilots, and align the program with U.S. carbon reduction commitments.

EPACT 2005	Energy Act 2020
Sec. 961 – Fossil Energy	Sec. 961 – Fossil Energy
Sec. 962 – Coal and Related Technologies Program	Sec. 962 – Carbon Capture Technology Program
Sec. 963 – Carbon Capture and Sequestration RD&D Program	Sec. 963 – Carbon Storage Validation and Testing

5

Build Back Better Bill – H.R. 5376

Key CCS and Other Provisions

- Section 45Q increase and extension (136106)
- Makes projects with CCS eligible for publicly traded partnership tax treatment (136107)
- $3.6 billion for DOE loan guarantee program (30441)
- Clean electricity PTC/ITC (136801/02)
- Clean fuel PTC based on lifecycle emissions (136805)
- Clean hydrogen PTC (136204)
- Title VII Subtitle N O&G fees
  - Offshore royalty rates, minimum bids, onshore rental rates, shortened lease term, expression of interest fee, non competitive leasing prohibition, per acre fees, inspection fees, severance fees, idled well fees, offshore pipeline owner fees, elimination of royalty relief
- $775 million to EPA for methane reduction grants (30114)

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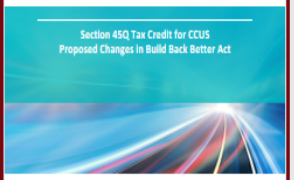


Section 45Q Tax Credit for CCUS
Proposed Changes in Build Back Better Act

David Lowman
Partner, Hunton Andrews Kurth LLP
December 7, 2021

1 ★

Build Back Better Act

The House of Representatives passed the Build Back Better Act ("BBBA") on November 19, 2021. The House Bill is currently under consideration in the U.S. Senate. The BBBA proposes to amend Section 45Q in a number of ways.

The amendments discussed below apply to facilities or carbon capture equipment the construction of which begins after December 31, 2021. Facilities or carbon capture equipment that begin construction before that date remain subject to the Code provisions, including the tax credit rate and other provisions, in effect before the amendment.

2

Section 45Q

Generally, the amount of the section 45Q credit and the party that is eligible to claim the credit depend on whether the taxpayer captures qualified carbon oxide using carbon capture equipment originally placed in service at a qualified facility before February 9, 2018 ("Old 45Q Facility"), or on or after February 9, 2018 ("New 45Q Facility"), and whether the taxpayer disposes of the qualified carbon oxide in geological storage ("sequestration"), uses it as a tertiary injectant in a qualified enhanced oil or natural gas recovery project ("EOR"), or utilizes the carbon oxide in certain specified ways ("utilization").

3

Production Thresholds

The BBBA will substantially reduce the production thresholds and add an efficiency requirement for electric generating facilities.

- A direct air capture facility must capture at least 1,000 metric tons per taxable year.
- An electricity generating facility must capture not less than 18,750 metric tons of qualified carbon oxide during the taxable year and not less than 75 percent by mass of the carbon oxide that would otherwise be released into the atmosphere by such facility during such taxable year.
- In the case of any other facility, it must capture not less than 12,500 metric tons of qualified carbon oxide during the taxable year.

4

Beginning of Construction

The beginning of construction date is extended to December 31, 2031. Subject to satisfying all other requirements, any project that begins construction by that date will qualify for the Section 45Q tax credit.

5

Tax Credit Base Rates

The current rate of $85 for utilization and use for EOR and $50 for sequestration are adjusted for facilities to which the amendments apply:

- For any taxable year before 2027, the "base rate" for utilization and use for EOR is $12. An inflation adjustment factor is added for taxable years beginning in 2027.
- For any taxable year before 2027, the "base rate" for sequestration is $17. An inflation adjustment factor is added for taxable years beginning in 2027.
- A special rate is provided for direct air capture. With respect to direct air capture, for any taxable year before 2027, the "base rate" is $36 for sequestration and $26 for utilization and use for EOR. An inflation adjustment factor is added for taxable years beginning in 2027.

6

Full Tax Credit Rate

The "base rate" is increased by a multiple of 5 for projects that satisfy prevailing wage and apprenticeship requirements. In other words, the base rate is multiplied by 5 to reach the full tax credit value.

- The full tax credit value for sequestration is $85 ($17 x 5)
- The full tax credit value for utilization and use for EOR is $60 ($12 x 5).
- The full tax credit rate for direct air capture is $180 for sequestration and $130 for EOR and utilization.

These rates are subject to inflation adjustment beginning in 2027.

7

Prevailing Wage and Apprenticeship Requirements

- The effective date for satisfying the prevailing wage and apprenticeship requirements is for facilities or carbon capture equipment that starts construction after the date that is 60 days after Treasury issues guidance on how to comply with the prevailing wage and apprenticeship requirements.
- Projects that begin construction after that date will have to satisfy the prevailing wage and apprenticeship requirements to get the full tax credit rate. Projects that start construction after that date which do not satisfy the requirements will get only the base rate, i.e., 20% of the full credit amount.
- Projects that begin construction after December 31, 2021 and before the date that is 60 days after the Treasury issues guidance will receive the full tax credit rate without satisfying prevailing wage and apprenticeship requirements.

8

Prevailing Wage Requirements

The prevailing wage requirement is as follows: Any laborers and mechanics employed by contractors and subcontractors in (i) the construction of a facility or carbon capture equipment, and (ii) for the 12-year period beginning on the date the facility or carbon capture equipment was originally placed in service, for the alteration or repair of such facility or carbon capture equipment, shall be paid wages at rates not less than the prevailing rate for construction, alteration, or repair of a similar character in the locality as most recently determined by the U.S. Department of Labor.

Note that the prevailing wage requirement is limited to construction, alteration and repair of the facility or carbon capture equipment. This activity should be limited to the project site. Payment of prevailing wages for alteration and repair continues for 12 years from the placed in service date and could affect the Section 45Q tax credit for any year in that 12-year period.

9

Prevailing Wage Requirements

Failure to satisfy prevailing wage can be corrected by paying the difference between the wages paid and the applicable prevailing wage to the affected workers plus interest and a $5000 per affected worker penalty to the IRS. If there is intentional disregard of the requirement, the payment is increased to *three times* the sum of the difference between wages paid and the applicable prevailing wage and interest, and the $5000 penalty per worker is increased to $10,000 per worker.

10

Apprenticeship Requirements

All contractors and subcontractors engaged in the performance of construction, alteration, or repair work on any project shall ensure that a percentage of the total labor hours of such work be performed by qualified apprentices. The percentage of total labor by apprentices phases in from 10% for projects that begin construction before January 1, 2023, 12.5% for projects that begin construction before January 1, 2024, and 15% for any project that begins construction after December 31, 2023.

There is a good faith exception to the apprenticeship requirement if the contractor has requested qualified apprentices from a registered program and the request is denied or not responded to within 5 days. If the good faith exception does not apply, the taxpayer can pay a penalty to the IRS of $50 for every hour that the requirement was not satisfied. There is an increased penalty for intentional disregard of the requirement.

11

Tax Exempt Financing

The credit is reduced if the facility or carbon capture equipment is financed with tax-exempt bonds. If tax-exempt bonds are used to finance the facility or carbon capture equipment, the credit is reduced by the lesser of 15 percent or a fraction the numerator of which is the tax-exempt bond proceeds used to finance the facility or carbon capture equipment and the denominator of which is the capital cost of the facility or carbon capture equipment.

12

Direct Pay

The BBBA provides an election for direct payment of the tax credit by the government to the taxpayer.

- The election applies to the Section 45Q tax credit that is attributable to carbon capture equipment that is placed in service after December 31, 2021 and for which an election is made.
- In the case of a taxpayer that is a corporation or individual, the amount of the tax credit is treated on the taxpayer's tax return as a payment of tax, like a payment of estimated tax. To the extent that the estimated payments, including the tax credit amount, is in excess of the tax liability on the tax return, the government (IRS) will issue a refund/payment of that amount to the taxpayer.
- For Section 45Q, the election is made for each separate qualified facility.

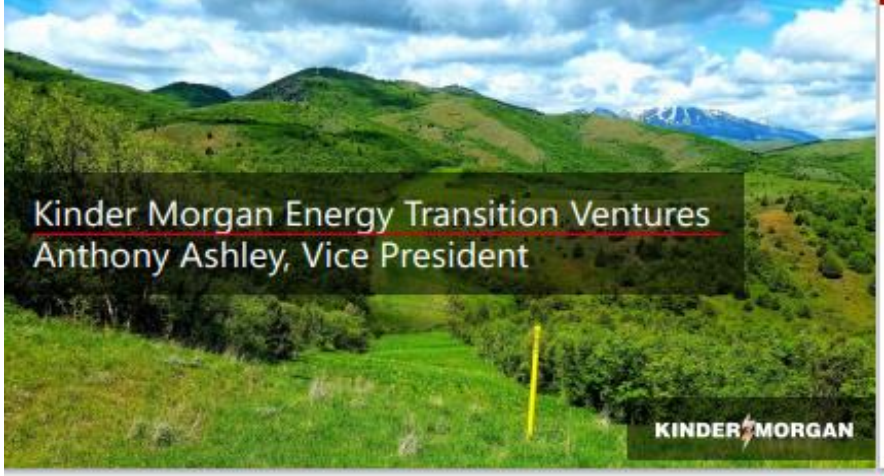
Direct Pay- Special Rules

Special rules apply for partnerships, S corporations, and tax exempt and government entities.

- In the case of a partnership or S corporation that directly owns carbon capture equipment and qualifies for the tax credit, the IRS will make a payment to the entity in the amount of the tax credit. Such payment is treated as tax exempt income to the entity.
- In the case of a tax-exempt or governmental entity, the election treats the tax credit amount as used in connection with a trade or business and allows the entity to receive a direct payment of the credit.

Direct Pay- Election

The election for direct pay will be made on the taxpayer's tax return. Such election must be made no later than the due date, including any extension, for the tax return for the taxable year in which the carbon capture equipment is placed in service. The election is irrevocable and applies to all taxable years for which the tax credit is claimed



Disclosure

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Forward-looking statements / non-GAAP financial measures / industry & market data

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Leader in North American Energy Infrastructure

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Unparalleled & irreplaceable asset footprint built over decades

Largest natural gas transmission network
- ~70,000 miles of natural gas pipelines
- ~700 bcf of working storage capacity
- ~1,200 miles of natural gas liquids pipelines

Largest independent transporter of refined products
- Transport ~1.7 mmbbl of refined products
- ~6,800 miles of refined products pipelines
- ~3,100 miles of crude pipelines

Largest independent terminal operator
- 144 terminals & 16 Jones Act vessels

Largest CO_2 transport capacity of ~1.5 bcfd
- ~1,500 miles of CO_2 pipelines

Sustainalytics ESG risk rating
- #1 in Refiners & Pipelines industry group (167 companies)
- #1 in Oil & Gas Storage & Transportation subindustry (161 companies)

Connecting major U.S. natural gas resource plays to key demand centers

Move ~40% of U.S. natural gas consumption & exports

BUSINESS MIX

Strategy

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Maximize the value of our assets on behalf of shareholders

Stable, fee-based assets

Core energy infrastructure

Safe & efficient operator

Multi-year contracts

>90% take-or-pay & fee-based cash flows

Invest in a low carbon future

Newly formed Energy Transition Ventures Group

$1.6 billion backlog with ~70% allocated to natural gas projects

Investing in natural gas, RNG, and liquid biofuels infrastructure at attractive returns

Financial flexibility

4.0x 2021 expected Net Debt / Adjusted EBITDA[a]

Long-term target remains around 4.5x

Low cost of capital

Mid-BBB credit ratings

Ample liquidity

Reduced net debt by >$12 billion since 3Q 2015

Disciplined capital allocation

Conservative assumptions

High return thresholds

Self-funding 100% of capex & dividends for last five years

Enhance shareholder value

Maintain strong balance sheet

Attractive projects

Dividend growth

Share repurchases

a) A non-GAAP financial measure. See Kinder Morgan, Inc. press release dated December 15, 2021 for definitions and reconciliations of non-GAAP financial measures.

Kinder Morgan Energy Transition Ventures

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Energy Transition Ventures group formed in Q1 2021 to evaluate step out commercial opportunities emerging from the low-carbon energy transition

Initially focused on the following verticals as they are most synergistic with KM existing infrastructure and expertise:
- RNG: largest Nat Gas transmission network, transport 40% of US Gas consumed/exported
  - $210MM Kinetrex Acquisition closed August 2021
- CCUS: largest CO2 transport network in North America, EOR expertise
- Biofuels (RD/SAF): handle ~25% of all biofuels (Ethanol/RD/Biodiesel) produced in US today
- Renewable Power: large asset base with substantial power demand across country
- Hydrogen: potential for blending in Nat Gas pipelines

ETV looking at vertical integration opportunities (RNG Production, CO2 Capture/Sequestration), existing business segments maintain focus on traditional transport/storage of low carbon fuels

Business Development group focused on capital deployment at economic returns consistent with corporate hurdle rates

Investment Horizon

RNG Provides an Immediate Low-Carbon Solution

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Proven & cost-effective means of decarbonization

Benefits of RNG
- Leverages existing natural gas infrastructure
- Utilizes reliable, low-cost feedstock
- Provides dispatchable and sustainable power
- Reduces fugitive emissions
- Promotes better waste management practices

AVERAGE CARBON INTENSITY

gCO2e/MJ

U.S. landfill RNG projects avoid annual emissions equivalent to

~2 billion pounds of coal burned

~218 million gallons of gasoline consumed

~234,000 homes' annual energy use

Source: EPA LandGEM and LFG Energy Project Database (September 2021 - Approximations based on the EPA's greenhouse gas equivalencies calculator. Average carbon intensities per the RNG Coalition.

$310 million Acquisition of Kinetrex Energy

Platform acquisition provides multi-year head start to participate in emerging RNG market

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ASSETS & VALUATION

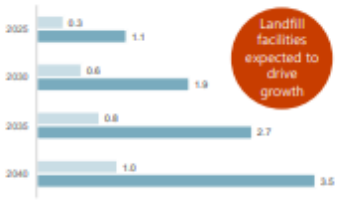
- 2 small-scale LNG facilities
- 1 operational landfill-RNG facility with ~0.4 bcf/d capacity
- 3 landfill-RNG facilities operational by 2022 end with total capacity of 3.5 bcf
- Offtake is commercially contracted with high quality counterparty
- Expect ~6x 2023 EBITDA based on $310mm purchase price and $135mm development capex
- Conservative RINs assumptions vs current spot RINs prices
- Transaction closed Aug 20, 2021

FUTURE RNG DEVELOPMENTS

- Retained Kinetrex management team to pursue new projects and expand RNG platform
- Mitigate exposure to RIN volatility through fixed price contracts in voluntary market

NORTH AMERICA RNG DEMAND bcfd

Stated Policies Scenario > Sustainable Development Scenario



Hundreds of landfills across the US are candidates for RNG
<100 sites operational or in development today

Sources: North America RNG Demand per IEA "Outlook for biogas and biomethane" report (March 2020); Landfill site data per EPA Landfill Methane Outreach Program (LMOP)
a) KMI share: 50% interest in Indy HBTU. 3 facilities in development are 100% owned.

RNG Capabilities

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Kinder Morgan's $310MM Acquisition of Kinetrex Energy Creates a "Best in Class" RNG Organization

- KM has unique competence across the RNG value chain
  - Production of RNG *(RNG facilities in production and under construction)*
  - Transport of RNG *(pipeline network and interconnect expertise)*
  - End-Use of RNG *(end-use customer acquisition)*
- Fundamental strategy consists of four key elements
  - ✓ Fully integrated model to extract maximum value
  - ✓ Direct end-use customer relationships
  - ✓ RNG production (*Kinetrex focused on landfill gas, also looking at AD projects)*
  - ✓ Focus on world-class scalable partnerships
- Kinder Morgan expertise in carbon capture could extend to landfills with proposed regulatory changes

Demand Markets Provide Diversification

Plan to mitigate exposure to RIN volatility through fixed price contracts in the voluntary market

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REVENUE EXAMPLE

$ per mmbtu

revenues must meet or exceed traditional hurdle rates

transportation market

RNG-based CNG & LNG is advantageous for fleets

- GHG emissions up to 75% less than diesel
- CNG vehicles are more efficient than electric vehicles for heavy & mid duty fleets looking to decarbonize
- Fleets are interested in RNG to meet emission reduction targets

RIN credits can be earned for RNG volumes used in the transportation market

- Drives the margin for RNG producers
- RFS-obligated parties (like refiners) purchase RINs to comply with RFS requirements

EPA considering creating eRINs to incentivize RNG used for electricity that charges electric vehicles

- Could create additional RNG demand and another avenue to capture RIN margin

voluntary market

LDCs, utilities, universities, industrial

- All active in the voluntary market today
- Showing increasing interest in RNG as they look to meet their emission reduction targets

Pay premium for RNG

- Due to absence of subsidy for producers
- Pricing is lower than current RINs value but terms are generally fixed for 10+ years

a) $3.47 D3 RIN price (as of 11/19/2021, per Starboard Brokerage via Bloomberg) multiplied by 11.727 to convert to $/mmbtu

Attractive Potential for Producing Renewable Fuels

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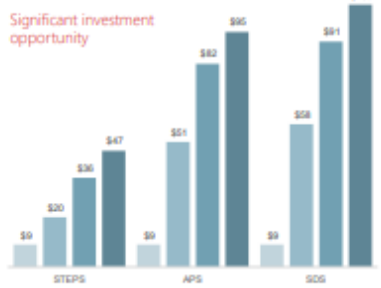
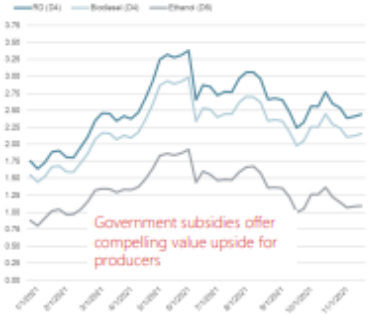
GLOBAL AVERAGE ANNUAL SPEND ON BIOFUELS & BIOGASES

$ billions ■2016-2020 ■2021-2030 ■2031-2040 ■2041-2050



2021 RIN VALUES $ per gallon



Left Source: International Energy Agency; World Energy Outlook, October 2021
Right Source: RIN Trades and Price Information | US EPA

Carbon capture key to meeting global climate agenda

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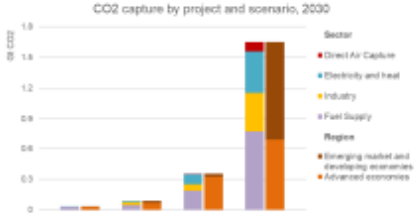
- Meeting net zero goals requires reducing emissions from hard to abate sectors
  - Heavy industry is 20% of global CO2 emissions
  - Alternative to traditional fuels can be cost prohibitive
  - CCUS is often cheapest option to reduce emissions
- Massive potential CO2 infrastructure build out needed for US to meet Net Zero by 2050*
  - > 1,000 CO2 Capture Facilities
  - > 100,000 km of CO2 pipelines
  - ~ $170 billion of capital required

CO2 capture by project and scenario, 2030



Note: Facilities = operating commercial CO2 capture projects or under construction (including two with operations currently suspended).
Source: IEA analysis and GCCSI (2021).

Achieving the level of CCUS needed to reach ambitions in the Announced Pledges Scenario (APS) requires targeted policy support and > 10x increase in current capacity

* Per Princeton University's Net Zero America: Potential Pathways, Infrastructure and Impacts Report

Captured Carbon may be Sequestered or used in EOR Production

Point source emitters are geographically diverse

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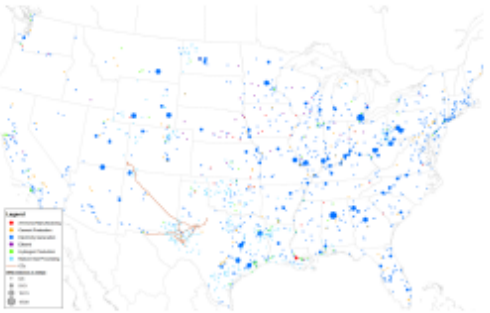

Within 30 miles of our existing CO2 pipe, we estimate carbon capture opportunities of:

~200-300 mmcfd	from natural gas processing/treating
~500 mmcfd	from natural gas power
~700 mmcfd	from coal power

KMI is a natural fit for facilitating CCUS

Substantial EOR experience

Have been developing CO2 pipeline & processing facilities for decades

Source: EPA Facility Level GHG Emissions Data

KM Positioned to Participate Across CCUS Value Chain

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Emission Sources	Capture	Transport	EOR / Sequestration
In discussions with emissions sources throughout North America on CCUS solutions	Evaluate opportunities to invest, construct, and/or operate	Largest CO2 pipeline operator in North America	Substantial EOR experience
Own gas processing, LNG and landfill RNG assets	Leverage existing capabilities including fabrication & processing expertise	1.5 bcfd Cortez pipeline delivers ~80% of the CO2 used for Permian EOR	EOR can benefit from 45Q today while sequestration options deal with lengthy permitting process
		Experts at developing & constructing CO2 pipeline – there are barriers to entry due to unique construction & design philosophy of CO2 pipe	Leverage downhole CO2 experience to assess sequestration locations
		Potential for conversion of existing KM pipelines in certain situations	Our source fields in Colorado could potentially be used for sequestration in the future

"Challenges to investment remain. Several characteristics of CCUS projects, such as the need for counterparty arrangements arising from complex chains of capture-transport-storage and the need for regulatory frameworks for long-term ownership/liability of stored CO2, bring a set of distinct risks" - IEA

CCUS Economics are Improving but Remain Challenged

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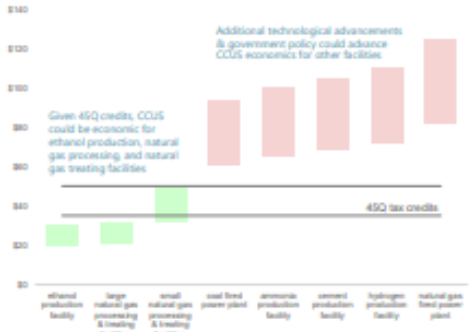
CURRENT ESTIMATED U.S. CARBON CAPTURE COST $/tonne



Source: KM analysis, National Energy Technology Laboratory
Note: Estimated costs are based on 20% IRR (real) on capture unit tailgate, no tax credits, and at pressure ready for pipeline.

45Q TAX CREDITS

- Capturer controls the tax credit
- Industry still contemplating economics across the value chain
- Proposed direct pay option could be a catalyst for CCUS

SEQUESTRATION

- $50/tonne deductible tax credit starting in 2027 ($85/tonne proposed in BBB)
- Lengthy EPA permitting process; only 3 permits ever issued
- States considering regulatory primacy to shorten permitting process, including Texas

EOR

- $35/tonne tax credit (beginning in 2027) is lower than for sequestration, but can be a quicker solution for a transaction today or a potential bridge ($60/tonne proposed in BBB)
- Our 1.5 bcfd Cortez pipeline delivers ~80% of the CO2 used for Permian EOR

Hydrogen/Renewable Power

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Hydrogen:

KM ETV looking at upstream/downstream ways to participate in Hydrogen economy value chain

- CCUS for Blue Hydrogen projects
- Hydrogen production facilities
- Hydrogen export opportunities
- Potential for participation in LCFS markets
- Development of hydrogen hubs

Natural Gas segment continuing to advance study of hydrogen blending into KM natural gas pipelines and evaluate hydrogen storage opportunities

KM ETV engaging with and monitoring Hydrogen market as it develops. Increased regulatory incentives could accelerate growth.

Renewable Power:

KM assessing best way to participate in renewable power projects that meet KM investment criteria and/or reduce Scope II Emissions

KM well positioned to participate in potential renewable power projects:

- Large power consumption footprint, primarily in locations favorable for renewable power deployment
- Own incremental land around asset base
- Creditworthy counterparty for PPA's

Key Takeaways

KINDER MORGAN

- Kinder Morgan well positioned to take advantage of energy transition opportunities
  - Breadth of assets, service offerings and existing skillset uniquely spans energy transition verticals
  - Flexibility to participate in all or individual aspects of the value chain
  - Substantial experience in building and operating pipelines and other assets in challenging regulatory environments in a safe and responsible manner
- Carbon management goals increasingly tailored toward reducing carbon intensity levels
  - LCFS markets growing and voluntary markets increasingly looking for lower CI products
  - Solution typically requires multiple energy transition product offerings
  - Kinder Morgan can be a one stop shop solution provider greatly reducing contractual complexity

EERC | UND UNIVERSITY OF NORTH DAKOTA

Energy & Environmental Research Center (EERC)

Lower-Carbon Oil Production via Captured CO_2 EOR and Associated Storage

19th Annual EOR Carbon Management Workshop
December 7, 2021

Nick Azzolina, Ph.D.

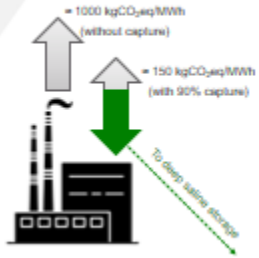
Presentation Outline

- Briefly review terminology used to quantify the carbon intensity of different products.
- Review "dedicated storage" and "associated storage" and what we mean by these two types of CCS/CCUS projects.
- Explain why incremental oil produced via EOR using captured CO_2 from an industrial source has a lower carbon intensity than any other oil in the marketplace.
- Highlight a few caveats and important details about the calculations.

Terminology Overview

- We commonly measure and track three greenhouse gases (GHGs):
  - Carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O)
- We express these three GHGs as "CO_2-equivalents" (CO_2eq) by multiplying the mass of each gas by its 100-year global warming potential:
  - (CO_2 x 1) + (CH_4 x 36) + (N_2O x 298) = CO_2eq
- The "carbon intensity" (CI) value of a product is the mass of CO_2eq per unit of product, e.g.,
  - $kgCO_2eq$/MWh electricity or $kgCO_2eq$/barrel oil
- Sometimes the CI value is expressed on an "energetics basis" (or other variants), e.g.,
  - gCOeq/MJ combusted gasoline

Dedicated Storage Math is (Relatively) Easy



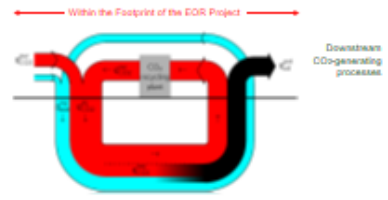
- "Dedicated storage" – CO_2 captured from an industrial source and permanently stored in a deep saline formation.
- Example:
  - A coal-fired power plant used to emit ~1000 $kgCO_2e$/MWh
  - We install a capture system running at 90% capture efficiency
  - Small additional coal mining, processing, and transport emissions.
  - Net emissions reduction of ~85%.

Associated Storage Math Gets Complicated

System boundaries for life cycle CO_2 emissions with CO_2-EOR

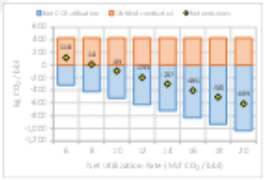
- "Associated storage" – CO_2 captured from an industrial source, utilized for EOR, and stored in the reservoir incidental to the CO_2-EOR process.
- Co-products (two or more products in the system, e.g., electricity and oil) complicate the GHG accounting.
- However, detailed studies have shown that the net result is an incremental oil with a lower carbon intensity than other crude oils.

>95% of the Purchased CO_2 is Stored in the Reservoir



Adapted from: van 't Veld, K., Mason, C.F., and Leach, J. (2013) The economics of CO2 sequestration through enhanced oil recovery. Energy Procedia, 37:6908-6919.

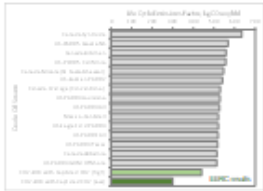
Start Simple: Just the Oil and the Net Utilization



- Historically, operators have tried to minimize net CO_2 utilization rates to improve the efficiency (and profitability) of CO_2-EOR.
- 6-10 Mcf/bbl (312-519 kg/bbl)
- 1 bbl oil combusted emits 430 kg/bbl
- Therefore, ~8.3 Mcf/bbl is the "break-even" point for oil combustion.
- Higher net CO_2 utilization rates >10Mcf/bbl further reduce the net emissions.

Expand the System to Include Up- and Downstream

- We must include:
  - Upstream emissions from the CO_2 capture source and
  - Downstream emissions from crude oil transport, refining, transport of refined fuels to point-of-sale, and fuel combustion.
- However, even with all these additions, the associated storage wins out and the incremental oil has a lower CI value.



Adapted from: Cooney, G., Jamieson, M., Marriott, J., Bergerson, J., Brandt, A., and Skone, T.J. 2017. Updating the U.S. life cycle GHG petroleum baseline to 2014 with projections to 2040 using open-source engineering-based models. Environ. Sci. Technol., v 21, p. 977-987.

Caveats and Other Considerations

- Every system is site-specific and has unique aspects to the GHG accounting.
- The upstream CO_2 source plays a large role in the final carbon intensity.
- The CO_2 capture rate (at the source) and net CO_2 utilization rate (of the EOR site) are generally the two most important variables to consider.
- As the share of the U.S. domestic crude production includes a larger proportion of incremental oil from captured CO_2-EOR, the overall carbon intensity of petroleum products – gasoline, diesel fuel, heating oil, and jet fuel – will decrease.

EERC | UND UNIVERSITY OF NORTH DAKOTA

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EERC | UND UNIVERSITY OF NORTH DAKOTA

Critical Challenges. Practical Solutions.

Federal CCUS Policy Update

Midland CO_2 Conference

Mike Weiner, Associate Director, Carbon Utilization Research Council

December 7, 2021

1

UNIQUE MISSION

With a global focus on reducing emissions from fossil fuel utilization, CURC's nonpartisan, technology-driven mission ensures the long-term value of fossil energy resources in an increasingly carbon-constrained world.

CONSENSUS DRIVEN & TECHNICALLY INFORMED

CURC brings technology developers and end users together. Our recommendations represent the consensus of our membership, including cutting-edge technical experts from a diverse set of interests in power generation.

SKILLED FACILITATORS

CURC is an established facilitator and trusted authority on advanced fossil energy technologies. We maintain productive working relationships with Members of Congress and the Department of Energy, and these entities turn to CURC for the most recent, fact-driven expertise and recommendations on federal policies affecting technology.

PIONEERING RESEARCH & GLOBAL COLLABORATION

CURC collaborates with world-class U.S. and international research organizations, and has been a driving force behind the crafting and passage of federal legislation, creating financial incentives for fossil fuel technology development and funding for research programs at the U.S. Department of Energy.

CURC.NET

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Carbon Utilization Research Council (CURC) Members

3

State of Play

- Infrastructure Investment and Jobs Act signed into law in November
  - Includes $1.2 trillion in federal investment for infrastructure programs, including $65 billion for power infrastructure
  - $12.1 billion included for CCUS-specific activities
- *Build Back Better* Act passed House of Representatives on November 19
  - Modifications likely in the Senate to get to 50 votes

4

Infrastructure Investment and Jobs Act

- Appropriations for CCUS Programs (five-year appropriation):
  - CCUS Demonstration Projects - $2.5 billion
  - CCUS Pilot Projects - $937 million
  - Carbon Storage Validation and Testing - $2.5 billion
  - Carbon Dioxide Infrastructure Finance and Innovation - $2.1 billion
  - Class VI Well Permitting - $75 million
  - Front-End Engineering and Design Studies for Carbon Dioxide Transport Infrastructure - $100 million
  - Carbon Dioxide Utilization - $310.14 million
  - Regional Direct Air Capture Hubs - $3.5 billion
  - Commercial Direct Air Capture Technology Prize - $100 million
  - Precommercial Direct Air Capture Prize - $15 million
- **TOTAL: $12.1 billion**
- DOE released RFI on Deployment-Ready Carbon Reduction and Removal Technologies on December 6
  - First RFI to be released by DOE directly stemming from infrastructure bill

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CCUS Highlights – Infrastructure Bill

- **CCUS Demonstration Program - $2.5 billion/five years**
  - Funding appropriated for six CCUS commercial demonstration projects – two each on coal power facilities, natural gas power facilities, industrial facilities
- **CCUS Large-Scale Pilot Projects - $937 million/five years**
  - As authorized, large-scale pilots defined to the scale of technology development beyond laboratory development and bench scale testing, but not yet advanced to the point of being tested under real operational conditions at commercial scale
  - DOE has more flexibility to award funds within pilot program – no specification of facilities that must be funded

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CCUS Highlights – Infrastructure Bill

- **CO_2 Storage Validation and Testing Program: $2.5 billion/five years**
  - Building on CarbonSAFE, appropriates funds for DOE cost share for integrated commercial CO_2 storage hubs capable of storing CO_2 from multiple sources.
- **CO_2 Infrastructure Finance and Innovation Act Program: $2.1 billion**
  - Establishes program to finance shared CO_2 transport infrastructure with federal credit instruments, loans, grants, or a combination
  - Eligible projects include carbon dioxide transportation infrastructure or associated equipment, including pipeline, shipping, rail, or other transportation infrastructure and associated equipment

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Build Back Better Act

- *Build Back Better Act* currently includes modifications to Section 45Q tax credit that reflect CURC priorities and recommendations:
  - Direct Pay
  - Extension of Commence Construction Deadline from December 31, 2025 to December 31, 2031
  - Increased credit value for all CCUS applications
    - Point source CCUS bonus credit value: $85/ton geologic storage; $60/ton EOR
    - DAC bonus credit value: $180/ton geologic storage; $130/ton EOR
    - Projects must satisfy 'Prevailing Wage and Apprenticeship requirements to qualify for bonus credit – projects receive "base" credit value if they do not ("Bonus" credit is 5x "base" credit)

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Build Back Better Act (cont.)

- Additional 45Q modifications:
  - Definition of Eligible Facility
    - Annual Tonnage Threshold Requirements
      - EGUs: 18,750 metric tons
      - Industrial Facilities: 12,500 metric tons
      - DAC Facilities: 1,000 metric tons
  - Facility-Wide Percentage Capture Requirements
    - EGUs: 75%
    - Industrial/DAC Facilities: N/A
- 45(b)(3) provision reducing value of 45Q for projects receiving other forms of federal assistance **modified** to only impact PABs (federal grants not impacted)

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Build Back Better Act (cont.)

- Outstanding issues on 45Q:
  - Facility-wide requirement to capture 75% of emissions for power sector CCUS projects left in place; industrial capture percentage requirement removed
  - Effective date of amendment changes:
    - Existing projects and projects beginning construction prior to January 1, 2022 are not eligible for increased credit values
- Other programs of interest currently included in reconciliation:
  - $40 billion for DOE Title XVIII Loan Program
  - $5 billion for DOE to provide financial support for Energy Community Reinvestment Financing Program, which enables low-carbon reinvestments in energy communities (CCUS may be an eligible expense)
  - CCUS eligible for $10 billion USDA grant/loan program for rural electric cooperatives to achieve GHG emissions reductions

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Thank You and Questions

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Federal Clean Hydrogen Policy Update

DECEMBER 7, 2021

CHFC Clean Hydrogen Future Coalition

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CHFC Foundational Principles

(1)Clean hydrogen is a critical pathway to achieve U.S. decarbonization objectives.
(2)Investments in the full value chain of clean hydrogen production, transport and delivery, storage and use, as well as the infrastructure across multiple sectors, will be necessary to scale clean hydrogen in the U.S.
(3)Policies designed to stimulate clean hydrogen production and use throughout the U.S. economy should be fuel agnostic and technology neutral, with a focus on achieving near-net zero CO_2 hydrogen production.
(4)Skilled labor and the use of existing infrastructure are essential to the deployment of clean hydrogen throughout our economy.

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CHFC Members

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Coalition Efforts to Support Mission

- Develop and communicate a clear message on the role of clean hydrogen in the transition to a zero CO_2 economy.
- Educate policymakers about the need for and benefits of clean hydrogen.
- Identify and prioritize policy designs to support clean hydrogen production, transport, delivery, storage, and end-use markets.
- Collaborate with other groups, stakeholders and environmental NGOs in the development of policies to support hydrogen.
- Advocate and lobby for federal legislative, regulatory and other policies that support the coalition mission.

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State of Play

- Infrastructure Investment and Jobs Act (H.R. 3684) signed into law in November
  - Includes $1.2 trillion in federal investment for infrastructure programs, including $65 billion for power infrastructure
  - $8.5 billion included for clean hydrogen-specific activities
  - Hydrogen refueling infrastructure also an eligible expense for Charging and Fueling Infrastructure Grant Program
- *Build Back Better Act* passed House of Representatives on November 19
  - Modifications likely in the Senate to get to 50 votes
- Other hydrogen-related legislation has also been introduced or is in development but will not be acted upon in 2021, including:
  - Hydrogen Infrastructure Initiative (Sens. Chris Coons and John Cornyn)
  - Clean Hydrogen Deployment Act (Reps. Paul Tonko and David McKinley)
  - Department of Energy Clean Hydrogen and Fuel Cell Research, Development, and Demonstration Act (*draft bill*)

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Infrastructure Investment and Jobs Act – Clean Hydrogen Provisions

REGIONAL CLEAN HYDROGEN HUBS - $8.5 billion/five years

- DOE directed to support the development of *at least* 4 regional clean hydrogen hubs, which are defined to mean a network of clean hydrogen producers, potential clean hydrogen consumers, and connective infrastructure in close proximity
- Hubs must reflect to the maximum extent practicable:
  - *Feedstock Diversity*: Requirement for at least one regional clean hydrogen hub to demonstrate hydrogen production from renewables, nuclear, and fossil fuels with CCS
  - *End-Use Diversity*: Requirement for at least one regional clean hydrogen hub to demonstrate end-use of clean hydrogen in the electric power, industrial, residential and commercial heating, and transportation sectors
  - *Geographic Diversity*: Each clean hydrogen hub must be located in a different region of the United States and use energy resources that are abundant in that region
  - *Hubs in Natural Gas-Producing Regions*: At least 2 regional clean hydrogen hubs must be located in regions with the greatest natural gas resources

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Infrastructure Investment and Jobs Act – Clean Hydrogen Provisions

CLEAN HYDROGEN ELECTROLYSIS PROGRAM - $1 billion/five years

- DOE directed to initiate a Clean Hydrogen Electrolysis Research, Development, Demonstration, Commercialization, and Deployment program for the purposes of commercialization to improve the efficiency, increase the durability, and reduce the cost of producing clean hydrogen using electrolyzers
- Program goal to reduce the cost of hydrogen produced via electrolysis to less than $2 per kilogram of hydrogen by 2026

CLEAN HYDROGEN MANUFACTURING AND RECYCLING - $500 million/five years

- DOE directed to award multiyear grants to, and enter into contracts, cooperative agreements, or other agreements authorized under the bill for RD&D projects to advance new clean hydrogen production, processing, delivery, storage, and use equipment manufacturing technologies and techniques

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Infrastructure Investment and Jobs Act – Clean Hydrogen Provisions

NATIONAL CLEAN HYDROGEN STRATEGY AND ROADMAP

- DOE directed to develop a technologically and economically feasible national strategy and roadmap to facilitate widescale production, processing, delivery, storage, and use of clean hydrogen.

CLEAN HYDROGEN RESEARCH AND DEVELOPMENT

- Manufacturer clean hydrogen RD&D activities at DOE with the following program goals:
  1. Advance research and development to demonstrate and commercialize the use of clean hydrogen in the transportation, utility, industrial, commercial, and residential sectors; and,
  2. Demonstrate a standard of clean hydrogen production in the transportation, utility, industrial, commercial, and residential sectors by 2050.

CLEAN HYDROGEN DEFINITION

- DOE and EPA directed to develop initial standard that defines the term 'clean hydrogen' to mean hydrogen produced with a carbon intensity equal to or less than 2 kilograms of carbon dioxide-equivalent produced at the site of production per kilogram of hydrogen produced
- DOE and EPA are directed to revisit whether the carbon intensity definition should be adjusted no later than five years after the initial standard is developed.

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Build Back Better Act

- Creates a Production Tax Credit (PTC) for clean hydrogen with a tiered incentive structure that rewards hydrogen production with the lowest carbon intensity
- Tax credits structured with "Bonus" and "Base" Credit Rate
  - Projects are eligible for "bonus" rate if they satisfy certain prevailing wage and apprenticeship requirement
  - "Bonus" rate – 5x "base" rate
- Direct Pay
- Projects claiming Clean Hydrogen PTC may also claim Section 45 renewable PTC, but not Section 45Q tax credit for carbon oxide sequestration
- Directs use of most recent GREET model to conduct lifecycle analysis up to point of production
  - Requires LCA definition to meet the CAA RFS definition
- Allows use of RECs to meet carbon intensity values

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Clean Hydrogen PTC in House *Build Back Better Act*

- Creates a Production Tax Credit (PTC) for clean hydrogen with a tiered incentive structure that rewards hydrogen production with the lowest carbon intensity
  - Five tiers
  - Top tier value – $4.00/kg of hydrogen produced with CI score of 0 – 0.45 CO2e/kg H2
- Tax credits structured with "Bonus" and "Base" Credit Rate
  - Projects are eligible for "bonus" rate if they satisfy certain prevailing wage and apprenticeship requirement
  - "Bonus" rate – 5x "base" rate
- Direct Pay
- Projects claiming Clean Hydrogen PTC may also claim Section 45 renewable PTC, but not Section 45Q tax credit for carbon oxide sequestration
- Directs use of most recent GREET model to conduct lifecycle analysis up to point of production
  - Requires LCA definition to meet the CAA RFS definition
- Allows use of RECs to meet carbon intensity values

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BBBA Clean Hydrogen PTC Credit Values

Lifecycle CO_2e/kg H_2	*Build Back Better Act* PTC ($/kg H_2) [Bonus/Base value based on % of credit]	CHFC Proposed Changes to *BBBA* PTC ($/kg H_2) [% of credit at $3.00 rate]
0 – 0.45	$4.00/$0.80 (100%)	Maintain
0.45 – 1.5	$3.03/$0.20 (44.4%)	$2.90 or $2.00 (84.4% or 67%)
1.5 – 2.5	$0.75/$0.15 (25%)	$2.00 or $1.50 (67% or 50%)
2.5 – 4.0	$0.60/$0.12 (20%)	$0.00 (44.4%)
4.0 – 6.0	$0.45/$0.09 (15%)	N/A

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Thank You and Questions

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MITSUBISHI HEAVY INDUSTRIES AMERICA, INC.

Carbon Capture for Marine / Ships

We support CC-OCEAN (Carbon Capture on the Ocean) together with Mitsubishi Shipbuilding.

Conceptual drawing of the CO_2 recovery demo plant

CC-OCEAN
CARBON CAPTURE ON THE OCEAN

PRESS INFORMATION

Mitsubishi Shipbuilding to Test World's First Marine-based CO_2 Capture System
-- "CC-Ocean" Project in Partnership with "K" Line and ClassNK Part of Japan Government Initiative to Support Development of Marine Resource Technologies --

Press Release on Aug 31, 2020
https://www.mhi.com/news/20083101.html

Successful KS-21 testing and high capture rate tests at TCM

MHI completed testing of its KS-21™ solvent at TCM on gas turbine and RFCC flue gas.

Parameters Relative to KS-1™	KS-1™	KS-21™
Volatility	100	50-60
Thermal degradation rate	100	30-50
Oxidation rate	100	70
Heat of absorption	100	85

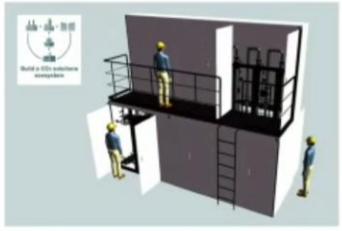
- KS-1™ and KS-21™ showed CO_2 capture rate of 95-98%, maximum 99.8%.
- KS-21™ showed lower emission and better energy performance than KS-1™ and MEA.

2021 Projects (Global)

Drax BECCS Project

Long term contract, announced June 10, 2021

Owner: Drax Power Limited
Location: North Yorkshire, UK
Project Information:
- At least 8 million tonnes of CO_2 annually
- World's first negative emissions project
- UK's first carbon capture project at scale
- Tested KS-1™ and KS-21™ solvent in 2020



Compact CO_2 Capture for Biomass

Delivery of system, announced December 1, 2021

Owner: Taihei Dengyo
Location: Hiroshima, Japan
Project Information:
- 0.3 tonnes per day
- 5m L x 2m W
- Small, modular design for mass production and easy installation

2021 Announced Projects (North America)

Lehigh Cement

Feasibility Study, announced January 21, 2021

Owner: Lehigh Cement
Location: Edmonton, Alberta
Project Information:
- 600,000 tonnes of CO_2 annually
- working with International CCS Knowledge Centre
- Funding from Emissions Reduction Alberta

Rio Grande LNG

Process Design Package, announced April 14, 2021

Owner: NEXT Carbon Solutions
Location: Port of Brownsville Texas
Project Information:
- 5 million tonnes of CO_2 captured total from facility
- Permanent sequestration
- EPC contractor: Bechtel

December 7, 2021

Wyoming Energy Strategy and CCUS Status

Midland CO_2 Conference

WYOMING ENERGY AUTHORITY

Dr. Glen Murrell

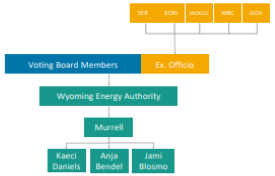
WEA

VISION

WEA advances Wyoming's energy strategy by driving data, technology, and infrastructure investments.

MISSION

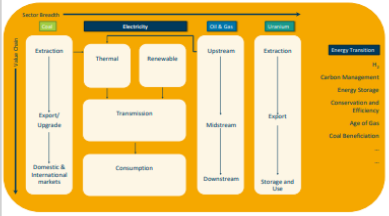
WEA supports and promotes Wyoming's energy sector by implementing the state's energy strategy; delivering positive economic impact and jobs for Wyoming, fostering an environment for the sustainability and growth of Wyoming's economy, and ensuring Wyoming continues to power the nation.



Core Activities

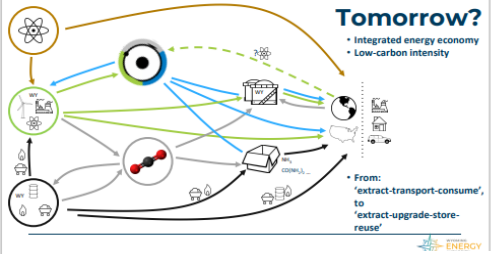
- **Advocacy** — Using evidence based reasoning to determine and advocate for the optimal policy, technology and economic solution.
- **Coordination** — Providing a framework for cohesive and coordinated development efforts.
- **Promotion** — Informing and educating the public and key stakeholders on policy, technology and development opportunities

Scope



... plus, non-energy extractives, like Trona, Bentonite, precious metals....

Tomorrow?

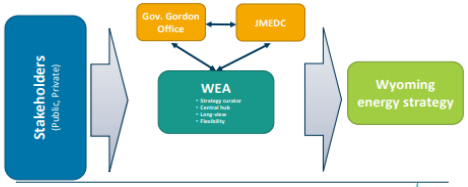


- Integrated energy economy
- Low-carbon intensity

- From: 'extract-transport-consume', to 'extract-upgrade-store-reuse'

Wyoming Energy Strategy

"...develop, administer, update and communicate the Wyoming energy strategy."



Wyoming Energy Strategy

Wyoming Energy

- **7,717 trillBTU (~$14.5B in product value) in 2018**
- **3rd largest producer in USA. If Wyoming were a country it would be ~13th largest, and roughly equivalent to Norway, Kazakhstan or the U.A.E.**
- **Coal @ $12t is cheaper than dirt: 40lb of top soil is $1.78 (~7.5X value)**
- **Oil @ $35bbl is cheaper than water: 1 Gallon of water is ~$1 (~$42 bbl)**
  - *Constituent product value (e.g. gasoline, diesel, jet fuel,...) is ~$80bbl*
- **Gas @ $2Mcf is cheaper than air: 80 cf tank refill ~$5 (~30X value)**
- **Electricity @ 10¢/KWh is simply darn cheap: $1 worth of electricity could boil a kettle of water 50 times**

ABUNDANCE = CHOICE

...and people are choosing low-emissions energy
...and their Governments are responding

Our North Star

EMPOWERING OUR NATION WITH A NET-ZERO ENERGY MIX

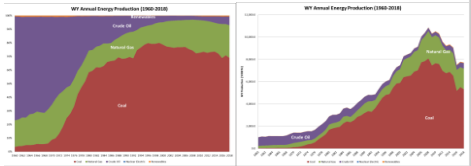
"...today, I challenge you to join me in making Wyoming net negative in CO_2 emissions. We have to take the lead, and not look back..... ,

*As we actively and thoughtfully collaborate with industry environmental groups, entrepreneurs, local communities, and others to produce our way to net negative carbon emissions, literally. Not by regulating away our past, **but by innovating our way to the future.**"*

- Gov. Gordon, State of the State address, March, 2, 2021

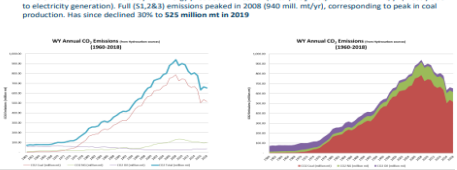
Strategic Opportunities

The Challenge



The Challenge

- WY's emissions are dominated by our Energy production. Internal (S1&2) CO_2 footprint ~90 mill. mt/yr (mostly due to electricity generation). Full (S1,2&3) emissions peaked in 2008 (940 mill. mt/yr), corresponding to peak in coal production. Has since declined 30% to **525 million mt in 2019**

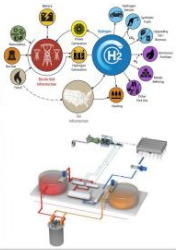


Key Initiatives

Hydrogen
- SER COE
- WEA Hydrogen RFP

Sequestration
- Pre-permit Class VI wells
- Public/Private commercialization of CCUS

Advanced Nuclear
- Value-chain development
- Education

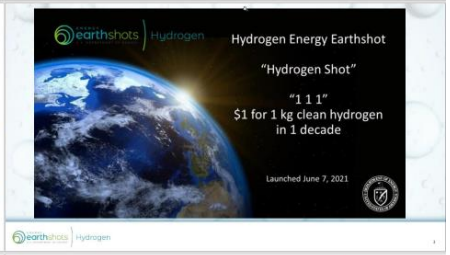


Why Sequestration?

- *Wyoming has an existing **CO_2 management infrastructure** already, which could be connected up to other CO2 pipeline systems*
- *Wyoming has abundant **reservoir storage capacity***
- *Wyoming has **Class VI primacy***
- *Wyoming established a strategic **pipeline corridor initiative***
- *It has a head start on many **policy** reqs.*
- *It benefits **ALL** CO2 emission sources including H2*
- *It would remove a great deal of uncertainty, liability and CAPEX from any emitters consideration*

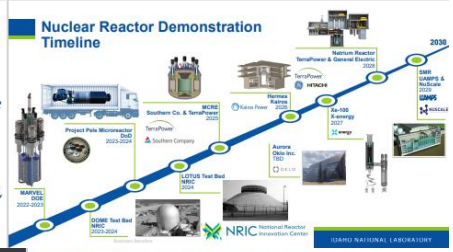
Why Hydrogen?

- *Wyoming has the **greatest abundance of natural feedstock for Hydrogen production in the country** (NG, Coal, Renewables)*
- *Its **geographical location** is favorable*
- *It has all the **ancillary export infrastructure** in place*
- *It has an existing substantial **CO_2 management infrastructure** already*
- *It has an existing **Hydrogen manufacturing** industry*
- *It has a head start on many **policy** needs*
- *It aligns with the **Wyoming Energy Strategy** and other economic initiatives in the state – "All-of-the-above", "Net-Zero", "Value-added", "energy and economic diversification", "innovate to the future"*



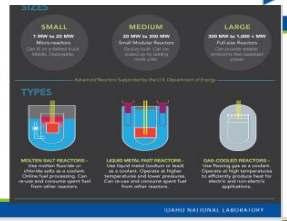
Why Advanced Nuclear?

- *Wyoming will host new **TerraPower Natrium** demonstration reactor*
- *Wyoming has **long-standing Ur mining history** and established ancillary energy infrastructure (transmission)*
- *Wyoming has considerable **existing logistic and supply chain** presence*
- *Integrates well with **low-emissions energy** economy*
- *Potential to provide **niche solutions** to industrial energy/emissions challenges*
- *It aligns with the **Wyoming Energy Strategy** and other economic initiatives in the state – "All-of-the-above", "Net-Zero", "Value-added", "energy and economic diversification", "innovate to the future"*



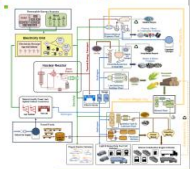
Advanced Reactor Technologies

- Enhanced passive safety
- Versatile applications due to range of sizes and ability to integrate with future energy needs
- Reduced cost by enabling factory fabrication
- Based on decades of research and development at DOE national laboratories



There is a role for nuclear with coal, natural gas, and wind & solar in Wyoming

- **Clean Power**- East and West
  - Zero-emissions fossil fuels
  - Wind
  - Nuclear
  - Energy Storage for Power Arbitrage
- **Carbon Conversion to High Value Product**
  - Natural Gas to Polymers and Hydrogen
  - Coal to carbon materials and rare-earths
  - Iron ore reduction and steel production
  - Minerals Processing
  - Fertilizers
  - Hydrogen for transportation systems
  - Hydrogen for emerging markets
  - Fabrication Shops



IDAHO NATIONAL LABORATORY

CCUS Status

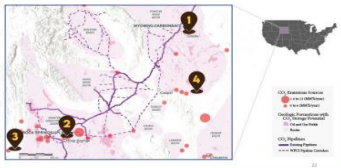
Public Sector	Private Sector
CarbonSAFE	Rocky Mountain Power REOI
Integrated Test Center - MTR	XOM Shute Creek
Pipeline Corridor Initiative	H2 + CCUS (6 projects)
Class VI Primacy	Industrial Source CCUS
ARP Capture Project ($200m)	CO_2 Import + Sequestration
ARP Sequestration Hub ($25m)	
WEA CCUS RFP ($10m)	
Sequestration as a Service	
State assumption of long-term stewardship	
State based accreditation framework	

*Post application submitted last week

UW Highlighted CCUS Projects

Carbon Capture and Storage (CCS) projects in Wyoming

1. Wyoming CarbonSAFE Project at Dry Fork Station
2. Rock Springs Uplift-Regional CCUS Hub
3. Depleted Gas Fields (Fold and Thrust)
4. Project Blue Bison (Blue Hydrogen)
5. Plains CO_2 Reduction Partnership (PCO$_2$R)-Regional effort



Wyoming CarbonSAFE: CO_2 Source and Capture

1. **Wyoming:**
   - ✓ CCUS legal Framework
   - ✓ Statewide CO_2 transportation network
   - ✓ Class VI Primacy (pending)

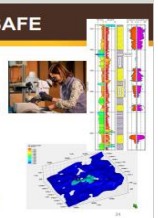
2. **Dry Fork Station:**
   - ✓ Built in 2007, on-line in 2011
   - ✓ 385 MW Coal-fired plant
   - ✓ 3.3 Million tons of CO_2/year
   - ✓ Operating life span through 2070

3. **Wyoming Integrated Test Center:**
   - ✓ Commercial-Scale Front-End Engineering Study for MTR's Membrane CO_2 Capture Process (DE-FE0031846)
   - ✓ UKY-CAER Heat-Integrated Transformative CO_2 Capture Process for Pulverized Coal Power Plants (DE-FE0031583)
   - ✓ Novel Next Generation Sorbent System for Post-Combustion CO_2 Capture – TDA Research, Inc. (DE-FE0031734)
   - ✓ Kawasaki Heavy Industries and JCOAL novel solid technology

Wyoming CarbonSAFE

Work completed to date:

- Geologic characterization: *Stratigraphic test well, 3D seismic, geologic modeling, risk analysis*
- Monitoring network: *Soil and water baselines established*
- Legal and regulatory analyses: *Model pore space leasing agreements, model CO2 off-take, Environmental Information Volume (EIV)*
- Economic modeling: *Web-based tool*
- Public Outreach: *Workshops, webpages, webinars, public presentations*



University of Wyoming Integrated Hydrogen/CCUS Projects

Initial engineering of the CO_2 capture unit of TEP *Blue Bison* ATR Plant

- Led by Tallgrass MLP Operations LLC (TEP), funded by the DOE
- FEED-type study on retrofitting an autothermal reforming (ATR) plant near Douglas, Wyoming with carbon capture that utilizes existing natural gas infrastructure
- Commercial scale system to separate and store 1.66 MT/year of CO_2 Sized for 220 MMSCFD of
- Operational goal of operations by 2025, with commercial H_2 sales/distribution via pipeline

Williams Wyoming Hydrogen Hub: Feasibility Study of Green Hydrogen Generation and Transport in SW Wyoming

- Led by Williams Companies Inc., funded by the WEA
- Green hydrogen feasibility with regional CCUS and water resource assessments
- Utilizes existing assets (land and power facilities) with a goal of lowering the carbon impact of existing business

UW School of Energy Resources

25

Membrane Technology and Research

ITC WYOMING INTEGRATED TEST CENTER

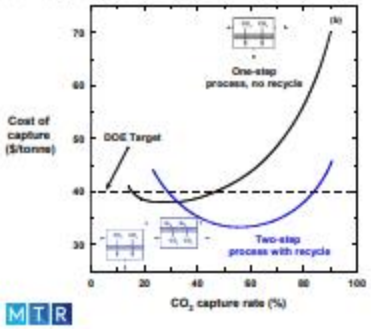
- MTR has a successful CO_2 capture research portfolio spanning more than a decade.
- 160-180 ton per day of liquid CO_2 product system will be located in the large test bay.
- $64 million total project cost.
- Kickoff meeting for Construction and Operation Phase November 5, 2021.
- Will capture approximately 70% of the CO_2. The most economical rate for $/tonne captured.

Membrane Technology and Research (MTR)

Tested at NCCC, TCM, and possibly WYITC.

Obviously a very compact solution.

MTR is completing a FEED study at Basin Electric's Dry Fork Station. Publicly shared CO2 capture cost curve:



MTR

December 3, 2021

https://netl.doe.gov/projects/files/Scale-Up%20and%20Testing%20of%20Advanced%20Polaris%20Membrane%20CO2%20Capture%20Technology%20FE0031591.pdf

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WYOMING ENERGY AUTHORITY

EERC | UND UNIVERSITY OF NORTH DAKOTA

Energy & Environmental Research Center (EERC)

CCUS Developments on the Northern Great Plains

Annual CO_2 Conference

EOR & Carbon Management Workshop

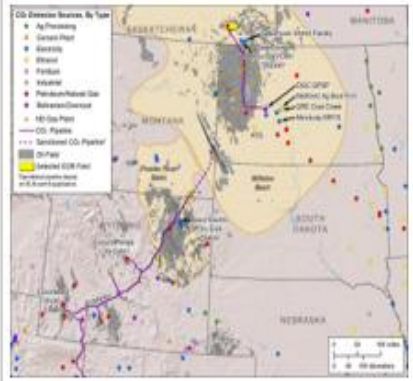
Midland, Texas

December 9, 2019

John Harju – Vice President of Strategic Partnerships

John Hamling – Director for Subsurface Initiatives

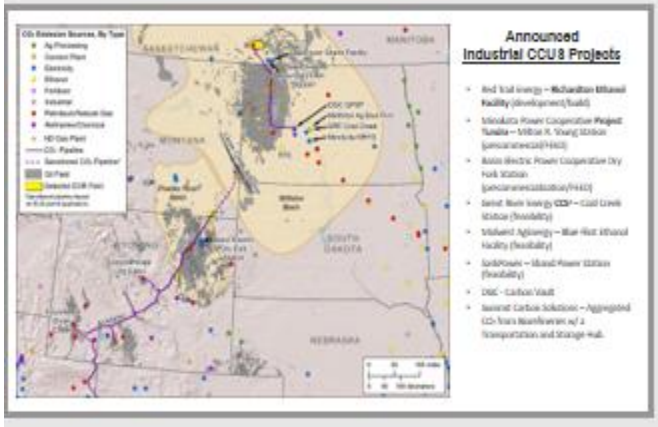
Kevin Connors – Assistant Director, Regulatory Compliance & Energy Policy



Industrial CCUS Projects

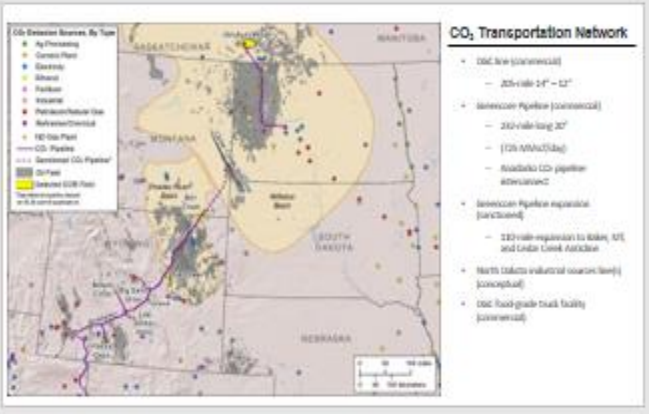
- Basin Electric Power Cooperative, Dakota Gasification Company (DGC) Great Plains Synfuels (commercial)
- Basin Electric Power Cooperative Dry Fork Integrated Carbon Capture and Storage (ICCS) Project (commercial)
- SaskPower Boundary Dam Carbon Capture Project (commercial)
- Exxon Mobil Shute Creek Natural Gas Processing (commercial)
- ConocoPhillips Lost Cabin Natural Gas Processing (commercial)
- Shell Quest CCS Facility* (commercial)—Alberta, Canada

*Not pictured



Announced Industrial CCUS Projects

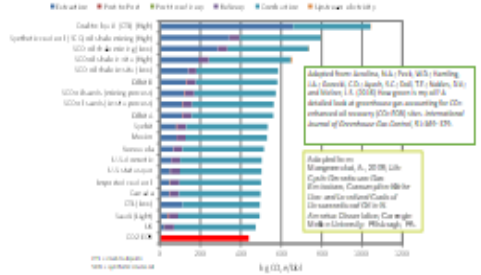
- Red Trail Energy – Richardton Ethanol Facility (development/build)
- Minnkota Power Cooperative Project Tundra – Milton R. Young Station (announced/FEED)
- Basin Electric Power Cooperative Dry Fork Station (announced/FEED)
- Summit Blue Energy CCS* – Coal Creek Station (feasibility)
- Midwest Agrienergy – Blue Flint Ethanol Facility (feasibility)
- SaskPower – Shand Power Station (feasibility)
- DGC - Carbon Vault
- Summit Carbon Solutions – Aggregated CO_2 from Northwestern w/ a transportation and storage hub



CO_2 Transportation Network

- DGC line (commercial)
  - 205-mile 14" – 12"
- Tamarack Pipeline (commercial)
  - 330-mile-long 20"
  - (135 MMscf/day)
  - Assiniboia CO_2 pipeline extension*
- Tamarack Pipeline expansion (sanctioned)
  - 330-mile expansion to Bakken, NPL and Cedar Creek Anticline
- North Dakota industrial sources (west) (conceptual)
- DGC food-grade truck facility (commercial)

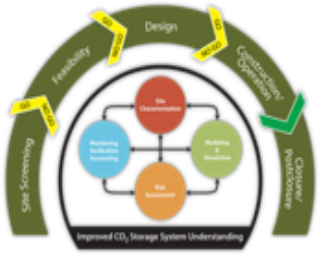
Life Cycle Analysis Results Indicate EOR with Captured CO_2 from Anthropogenic Sources Results in Lower-Carbon-Intensity Oil



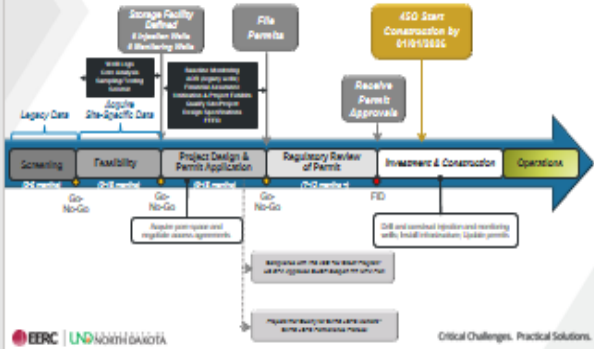
EERC

ADAPTIVE MANAGEMENT APPROACH TO PROJECT IMPLEMENTATION

- Staged approach to manage uncertainty and inform investment strategy.
- Implementation can be accelerated.
  - Higher investment needed at lower levels of confidence
  - Concurrent vs. sequential development
  - Balance financial and technical risk.
    - Site qualification
    - Permitting
    - Investment
    - Lost revenue/opportunity
    - IRAD start of construction



GENERALIZED TIMELINE TO IMPLIMENT GEOLOGIC CO_2 STORAGE



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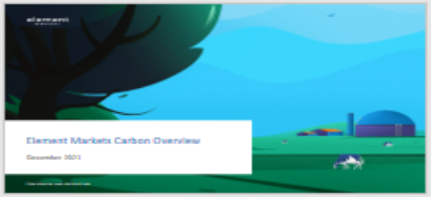
Critical Challenges. Practical Solutions.

1



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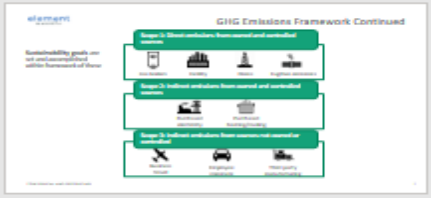

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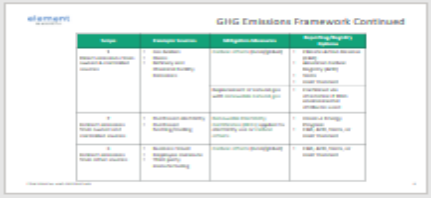

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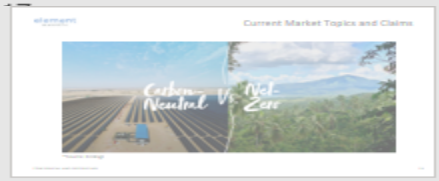

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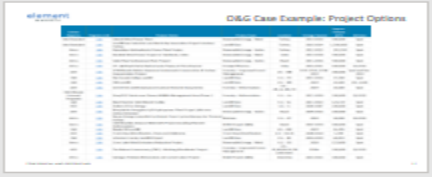

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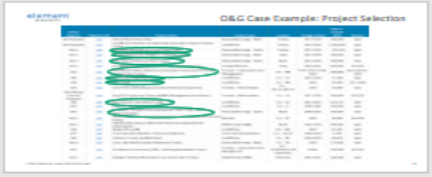

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Texas University Lands

- Open for business
- Land surface, subsurface, pore space etc all under one owner
- Large contiguous areas of land

Joe Quoyeser | Interim Chief Executive Officer | University Lands

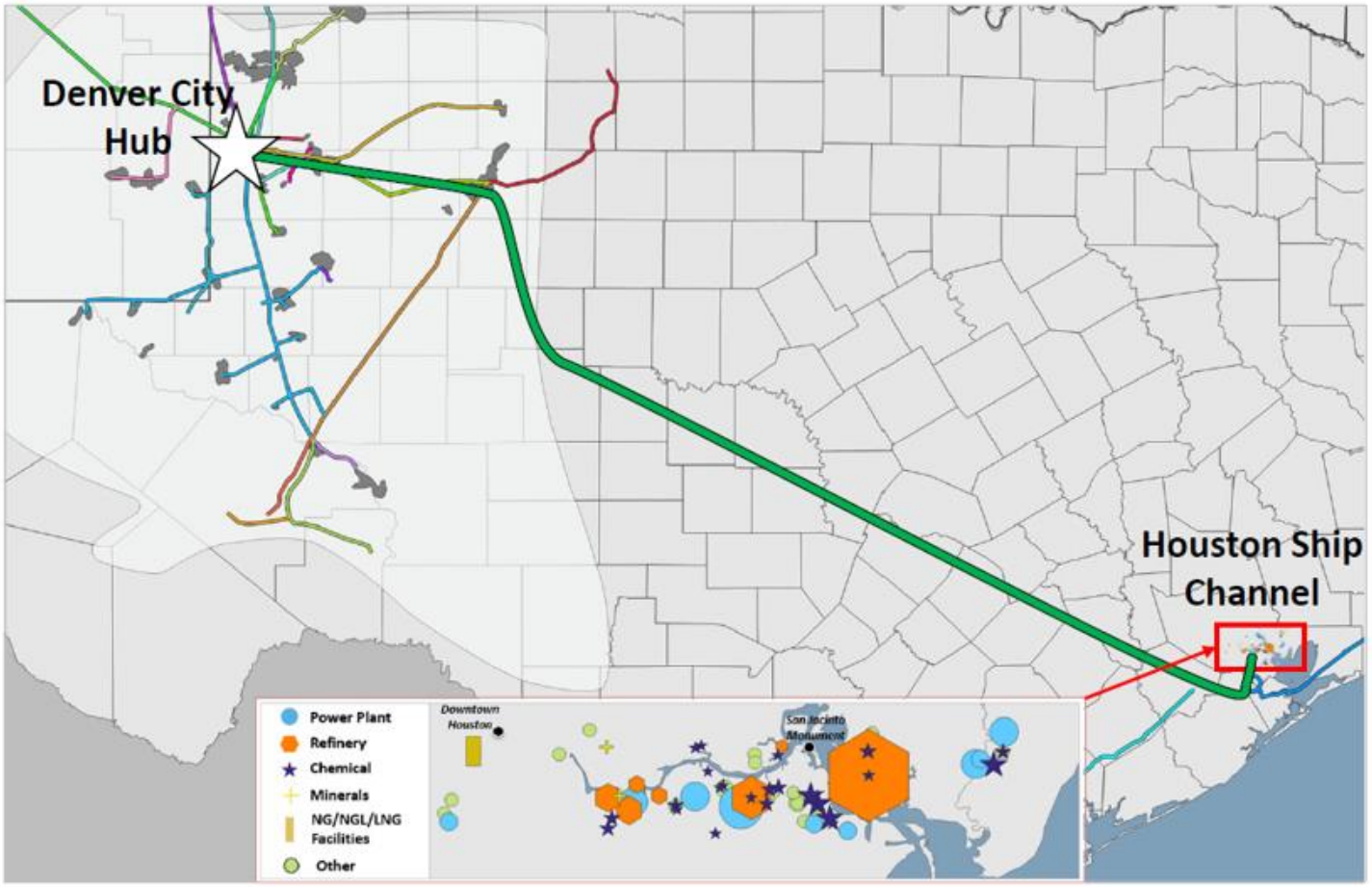
825 Town & Country Lane, Suite 1100 | Houston, Texas 77024

Main: 713.352.3808 | Direct: 713.352.3810 | Cell: 713.301.9866 | http://www.utlands.utsystem.edu

UNIVERSITY LANDS

Rusty Braziel-Reception

"I Can't Get No Sequestration" Ensuring CCUS/EOR's Major Role in Energy Decarbonization



Day 2

CCS Risk Management

Fred Eames, Partner
December 8, 2021

HUNTON ANDREWS KURTH

1

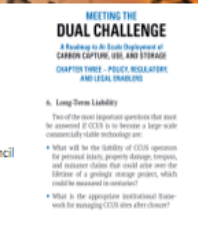
CCS Risk Management Experience

- Co-Founder, CCS Alliance
- Drafted federal and State CCS risk legislation
- Advocacy on Class VI financial responsibility regulations/guidance
- Co-Author, The Layered Approach to Risk Management for Geologic Sequestration of CO2

2

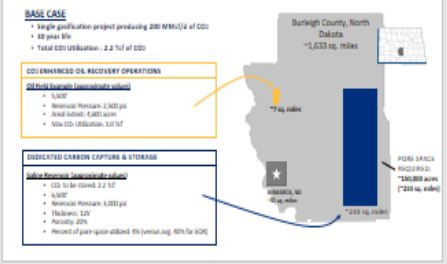
Why Are We Discussing Risk Management?

- Significant industry interest in initiating Class VI storage projects
- Major focus from Congress in fostering Class VI storage
  - $2.5 billion in Bipartisan Infrastructure Bill for carbon storage projects
- 2019 National Petroleum Council report *Meeting the Dual Challenge* identified CCS risk management as a key priority



3

Oil Field Utilization versus Dedicated CCS



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EOR and Dedicated Storage

EOR	Dedicated Storage
• Known history of containment in the formation	• Less known or unknown history of containment in formation
• Extensive industry experience	• Less mature industry experience
• Comparatively small areal extent	• Comparatively large areal extent
• Pressure equilibrium generally maintained	• Potential pressure management issues
• Brines produced, reinjected	• Brine management tbd
• Fewer property owners	• More property owners

6

CCS or CCUS?

	CCS	CCUS
Pros	• Higher 45Q tax credit amount ($50/ton vs. $35/ton) • Broader support from environmental community • Less interconnected project risk (offtakers don't need CO2, facility is down, etc.)	• Well-known low containment risks • Much smaller storage footprint • Lighter-handed regulatory structure (Class II vs. Class VI UIC program), state regulatory lead
Cons	• More difficult regulatory structure; EPA lead • Larger project footprint – property rights, public intervention • Less well-known containment – liability risk?	• Interconnected project risk • Lower 45Q tax credit amount (balanced by fee for CO2) • Environmental community resistance • Future fossil fuel production risk?

Offtakers may have dual capability

7

Necessity of Risk Management for Class VI Storage

- **UIC program requires Financial Responsibility** – 40 CFR 146.85
  - Purpose of UIC program is to protect USDWs
  - Must be sufficient to cover cost of corrective action, injection well plugging, post injection site care and site closure, emergency and remedial response
  - Variety of mechanisms approved for use
- **Market will require risk management**
  - Risk management likely required for financing
  - Market may distinguish between storage options based on credibility of risk management

8

Key Class VI Requirements – 40 CFR 146.85

- Specifies types of instruments allowed:
  - trust funds, surety bonds, letter of credit, insurance, self-insurance, escrow account, other "acceptable to the Director"
- "[M]ust be sufficient to address endangerment of underground sources of drinking water"
- Must maintain coverage "for the entire term of the geologic sequestration project" (essentially, until closure)
  - Certain restrictions on cancellation and renewal of instruments
- Risk management must be based on an estimate of costs of corrective action on wells in the AoR, plugging, PISC, closure, and emergency/remedial response (adjusted annually for inflation)
  - Director must approve estimate increases/decreases
- Must notify Director if "adverse financial conditions . . . May affect the ability to carry out injection well plugging and [PISC] and site closure"

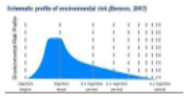
9

Types of Risk Management Instruments

Trust Fund | Insurance | Surety Bond
Letter of Credit | Self Insurance | Escrow

Or any other instrument acceptable to the Director (EPA or the State)

Risk and the Storage Site Timeline



- Pre-injection
- Injection
- Post-injection site care (PISC)
- Post-PISC (long-term)

Risk Management Considerations

Considerations in Risk Management

- Protecting human health and the environment, including USDWs
- Cost of risk management
- Encouraging a proper level of caution (moral hazard)
- Regulatory capture
- Assurance over a long term
- Market-driven solutions, not government-driven solutions
- Ability of society to put risk capital to work (dead capital problem)

Contact

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Asset Integrity Management Underpinning Safe & Secure Geological CO_2 Storage & Reducing Risk & Liability

Jessica Raines
OFS Global Discipline Lead – CCUS / UGS
Baker Hughes

1

New drivers in the CCS/CCUS Market

Infrastructure Investment and Jobs Act – IIJA (aka Bipartisan Infrastructure Bill)
- $1.2 trillion dollar investment in "traditional" infrastructure – transportation, energy, broadband, etc.
- Signed into law by President Biden Nov. 15, 2021
- Key CCUS provisions – SCALE Act, transportation, storage, permitting
- Key Hydrogen provisions – 'Clean' standardization

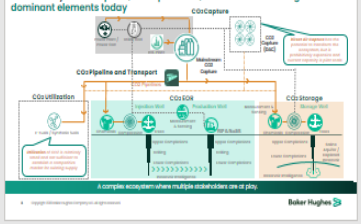
Build Back Better Act 2021 – BBBA (aka Budget Reconciliation Bill)
- $1.75 trillion dollar investment in social safety net and climate change
- Can be passed with only Democratic support but requires 100% of Senate Dems
- Outlook: Uncertain
- Key CCUS provision – 45Q enhancements
- Key Hydrogen provisions –

Recovering oil prices

Baker Hughes

2

CCUS ecosystem: Capture, Transportation, Utilization and Storage are the dominant elements today



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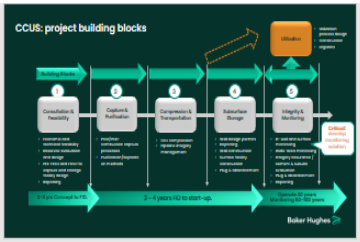
3

CCUS: project building blocks



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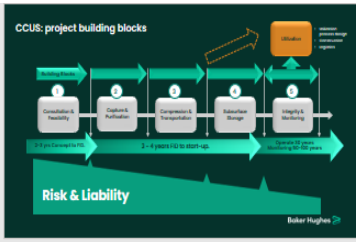
4

CCUS: project building blocks



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5

Why focus on risk and liability? Why now?

- Global ramp-up in CO_2 capture
- Understanding R&L will help to construct business models
- Properly vetted business models will showcase where along the operational chain insurance is most needed
- Defined models help to define best business practices & industry standards

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6

Different Business Models Unfolding

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7

Potential Insurance Models

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8

Asset Integrity Management (AIM)

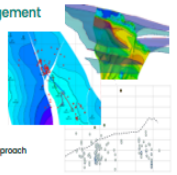
Underpinning insurance policy is the assurance that unacceptable outcomes will be mitigated, managed or prevented by proper management of the CO_2 injection asset.

Process of Asset Integrity Management:
- Assessment of topside risk and management strategy
- Subsurface asset identification
- Assurance of secure geological storage
- Risk assessment and monitoring plan
- Measurement, verification and reporting

Baker Hughes

9

Why Asset Integrity Management



- Required by UIC & GHGR programs
- Gain public acceptance
- Required for 45Q or CA LCFS
- Manage and track risk of unacceptable outcomes
- Develop a consistent and repeatable approach
- Ensures industry longevity

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10

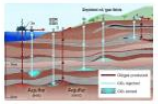
Details of the complications around AIM – Subsurface

Baker Hughes

11

What are the storage options?

- Storage options in Conventional Geologic Formations
- Storage options in Unconventional Geologic Formations
- Storage in Offshore Geologic Formations
- Storage in Depleted Hydrocarbon Reservoirs
- Other Geologic Storage Options



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12

Sequestration Iterative Workflow

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13

AIM Site Characterization

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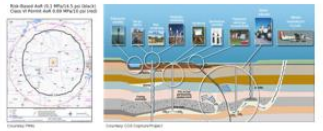
CO_2 storage monitoring requires a range of solutions over a large area



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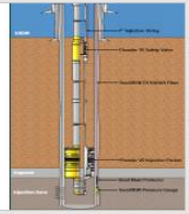
CO_2 Field Completion Design

- CO_2 injection Well Design
- Class II to Class VI
- Proper P&A
- Monitoring System installation



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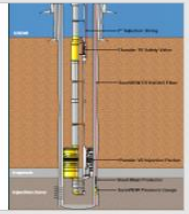
Conversions to Monitoring Well

- Accurate CBL
- Packer selection and placement
- Monitoring systems



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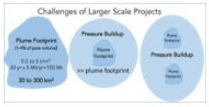
Challenges of large-scale projects include inefficient use of pore space as well as AOR overlap

Leases of underground pore space and surface access
Monitoring requirements over large area are expensive



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AIM Strategy

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Conclusions

- Market growth continuing a positive trend
- The CCS/CCUS ecosystem is complex with multiple levels of risk
- New business models are presenting themselves
- Risk and Liability must be understood to address and insure these business models
- The market is becoming increasingly complicated
- The time for consideration is now.

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Thank You

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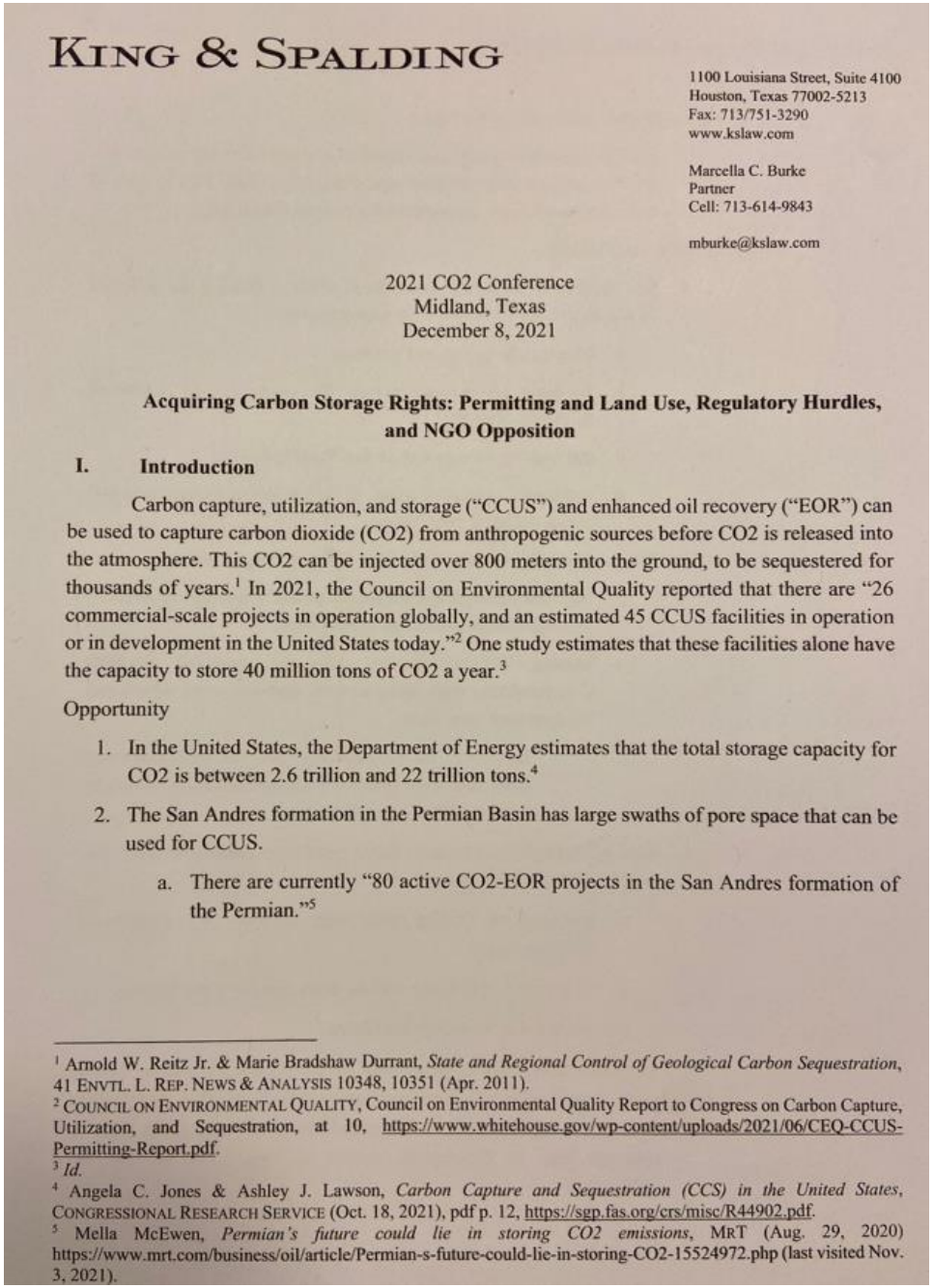

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2021 CO2 Conference
Midland, Texas
December 8, 2021

Acquiring Carbon Storage Rights: Permitting and Land Use, Regulatory Hurdles, and NGO Opposition

I. Introduction

Carbon capture, utilization, and storage ("CCUS") and enhanced oil recovery ("EOR") can be used to capture carbon dioxide (CO2) from anthropogenic sources before CO2 is released into the atmosphere. This CO2 can be injected over 800 meters into the ground, to be sequestered for thousands of years.[1] In 2021, the Council on Environmental Quality reported that there are "26 commercial-scale projects in operation globally, and an estimated 45 CCUS facilities in operation or in development in the United States today."[2] One study estimates that these facilities alone have the capacity to store 40 million tons of CO2 a year.[3]

Opportunity

1. In the United States, the Department of Energy estimates that the total storage capacity for CO2 is between 2.6 trillion and 22 trillion tons.[4]
2. The San Andres formation in the Permian Basin has large swaths of pore space that can be used for CCUS.
    a. There are currently "80 active CO2-EOR projects in the San Andres formation of the Permian."[5]

[1] Arnold W. Reitz Jr. & Marie Bradshaw Durrant, *State and Regional Control of Geological Carbon Sequestration*, 41 ENVTL. L. REP. NEWS & ANALYSIS 10348, 10351 (Apr. 2011).
[2] COUNCIL ON ENVIRONMENTAL QUALITY, Council on Environmental Quality Report to Congress on Carbon Capture, Utilization, and Sequestration, at 10, https://www.whitehouse.gov/wp-content/uploads/2021/06/CEQ-CCUS-Permitting-Report.pdf.
[3] *Id.*
[4] Angela C. Jones & Ashley J. Lawson, *Carbon Capture and Sequestration (CCS) in the United States*, CONGRESSIONAL RESEARCH SERVICE (Oct. 18, 2021), pdf p. 12, https://sgp.fas.org/crs/misc/R44902.pdf.
[5] Mella McEwen, *Permian's future could lie in storing CO2 emissions*, MRT (Aug. 29, 2020) https://www.mrt.com/business/oil/article/Permian-s-future-could-lie-in-storing-CO2-15524972.php (last visited Nov. 3, 2021).

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October 2021

- **Shari Ring – CADMUS Group**
- With the help of The Cadmus Group, USEA is releasing the study "Carbon Capture, Utilization, & Sequestration: A State Comparison of Technical and Policy Issues." **This study evaluates laws, policies, and regulations governing CO_2 storage operations and geologic storage across ten states including: Alabama, California, Indiana, Kansas, Louisiana, Michigan, Mississippi, Nebraska, Oklahoma, and Utah.** As a result of the expanded interest in CCUS due to the amended 45Q tax credit and the urgency of decarbonization, it is increasingly important for prospective CCUS project operators, legislatures and policy makers to understand legal and regulatory challenges to a more integrated and widespread implementation of CO2 storage. In addition to providing an oversight of the storage capacity and pipeline infrastructure of the states, this project provides comprehensive and comparative analysis of four dimensions of CO_2 law, regulation, and policy:
- 1) land use, mineral, water, and pore space rights;
- 2) geologic CO_2 storage and incremental storage regulation;
- 3) eminent domain; and
- 4) regulation of CO_2-EOR, oil and gas activities, and CO_2 pipelines.
- The study suggests opportunities to harmonize energy policies and address regulatory gaps and inconsistencies. The aim of this study is to facilitate better understanding of the legal underpinnings that frame risk, uncertainty, and investment in CO_2 utilization and storage infrastructure and projects, and to provide a roadmap for changes which are conducive to project development.

https://usea.org/sites/default/files/event-/CCUS%20State%20Comparisons%20Report.pdf

Questions & Thank You!

Michael E. Moore - Program Director – Annual CO2-EOR Carbon Management Workshop Midland, TX www.co2conference.net

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