2019 CO_2 EOR Carbon Management Workshop Program Recap - *17th year*

Michael E. Moore Workshop Program Director

EWSA

Midland, Texas December 12, 2019

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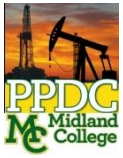

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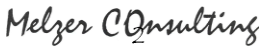

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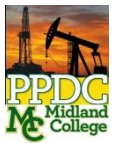

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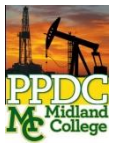

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2019 Workshop Agenda

8:00 - 8:30	EOR Carbon Management Workshop Opening Remarks Mike Moore & Steve Melzer
8:30 - 9:00	Vello Kuuskraa CEO ARI and latest on CO2-EOR
9:00 – 9:30	Brad Crabtree of GPI & Carbon Capture Coalition: Activities & CO2 Infrastructure
9:30-10:00	Fred Eames Partner Hunton Andrews Kurth: DC and CCUS related Policy Developments
10:00 - 10:30	Break
10:30 – 11:00	Mark Coalmer CCUS Projects Director OGCI Climate Investments LLP
11:00 - 11:30	Barry Worthington Executive Director of USEA: The World View on Energy and CCUS
11:30 – 12:00	John Harju of EERC/PCOR Current Programs and "Project Tundra"
12:00 - 1:00	Lunch and Keynote Speaker - Darrell Ricketson, Vice President Kinder Morgan CO2 and Chief Operating Officer
1:00 - 2:00	Public Pressures, CSR-ESG and Carbon Management - Nigel Jenvey Director Global Carbon Management - Gaffney-Cline, Charles McConnell Energy Center Officer of the Center for Carbon Management and Energy Sustainability University of Houston, Michael Moore Moderator Managing Partner EWSA.
2:00 - 2:30	Break
2:30 - 3:00	Kenneth Nemeth Executive Director Southern States Energy Board: Updates and Activities (ICCUS)
3:00 - 3:30	Tiffany Wu Mitsubishi Heavy Industries: Latest on CCUS Technology
3:30 - 4:00	Traci Rodesta Manager Carbon Storage Technology Manager NETL Developments & Insights
4:00 - 5:00	Tracy Evans – CEO Perdure, Keith Tracy Cornerpost CO2, David Lowman Partner Hunton-Andrews-Kurth All about 45Q
5:00 - 5:30	Patricia Loria - Senior Climate Engagement Lead Global CCS Institute: Global CCUS
5:30 - 5:45	Closing Session Review Wrap-Up Mike Moore and Steve Melzer
5:45	Adjourn to Reception in New Bush Convention Center

Vello Kuuskraa ARI

Advanced Resources International, Inc.

Role of CO_2 EOR for Carbon Management

Prepared for:
Carbon Management Workshop

Prepared by:
Vello A. Kuuskraa, President
Advanced Resources International, Inc.
Arlington, VA

December 9th, 2019
25th Annual CO_2 & ROZ Flooding Conference
Midland, TX

Our history of services:

Since 1971*, we have added value to hundreds of oil and gas E&P projects in the U.S. and in over 30 countries, from Australia to Zimbabwe.

Our approach integrates geology and geophysics, petroleum engineering, and strategic and economic analysis.

We specialize in enhanced oil and gas recovery and the geological storage of CO_2.

*From 1971 – 1987, the company was called Lewin & Associates; from 1987 – 1991, the company was a subsidiary of ICF Consulting/Kaiser Engineers; since 1991, the company is stand alone and called Advanced Resources International, Inc.

Our clients include:

Assertion #1: CO_2 EOR Provides, at Best, a Niche Opportunity for Carbon Management

Response #1: Not so!

- The technically viable CO_2 storage capacity offered by applying CO_2 EOR to conventional onshore oil fields and to the Permian Basin's residual oil zone (ROZ) is 83,600 million metric tons, enabling 1,000 million metric tons (40% of CO_2 emissions from domestic point sources) to be stored for 84 years.
- Adding potential CO_2 storage capacity from applying CO_2 EOR to offshore oil fields and shale oil formations would notably increases these numbers.
- Nine of the ten large-scale CCUS projects active in the U.S. involve CO_2 EOR; five of the nine large international CCUS projects involve CO_2 EOR.

Assertion #2: Storing CO_2 and Producing Oil with EOR Adds to the Carbon Management Problem

Response #2: Not so!

- The demand for oil, not the supply of oil, primarily governs how much oil is used and combusted.
- A barrel of oil produced using CO_2 EOR and associated CO_2 storage displaces a barrel of oil produced conventionally with no storage of CO_2.
- CO_2 EOR can store more CO_2 than the CO_2 contained in a barrel of oil when combusted.
  - CO_2 content of a barrel of oil is 0.43 metric tons; with 12% used for chemicals and other products, the combusted portion of a barrel of oil provides 0.38 metric tons of CO_2 per barrel.
  - For CO_2 EOR, the injected CO_2 to oil produced ratio for economically viable projects is 0.46 to 0.48 metric tons per barrel.

Assertion #3: CO_2 EOR With Associated CO_2 Storage Is a High Cost Option Not Viable at Near-Term Oil Prices

Response #3: Not so!

- At a $60/B oil price and a $25/mt CO_2 price (delivered), the economically viable CO_2 storage capacity offered by applying CO_2 EOR to conventional onshore oil fields and the ROZ is about 37 million metric tons, enabling 500 to 1,000 metric tons (20% to 40% of CO_2 emissions from domestic point sources) to be stored for 37 to 74 years.
- The U.S. Energy Information Administration's AEO 2019 projects oil prices of $78/B (WTI) by 2025 and $100/B by 2040 (2018 $/B), although oil prices in AEO 2020 will likely be about $20/B lower.
- "Next Generation" CO_2 EOR technology, involving advanced reservoir characterization conformance practices and real-time feedback and control methods, would notably improve CO_2 EOR performance and its economic viability.

Assertion #4: CO_2 EOR with Associated CO_2 Storage Can Meet Essentially All CO_2 Storage Needs

Response #4: Not so!

- Significant volumes of point source CO_2 emissions exist in the Northeast, the Mid-Atlantic, the Southeast portions of the country.
- The great bulk of the CO_2 EOR potential exists west of the Louisiana/Mississippi state line, particularly in West Texas, requiring long distance CO_2 trunklines from CO_2 sources to oil fields.
- Meanwhile, "world class" CO_2 storage opportunities exist in geologic (saline) formations in the SE and Gulf Coast areas of the country close to CO_2 sources.
- CO_2 EOR and geologic (saline) formations will likely provide equal volumes of CO_2 storage for CO_2 capture.

Assertion #5: The Costs and Challenges of CO_2 Capture Will Severely Limit Available CO_2 Supplies, Even with 45Q Tax Credits

Response #5: Not so!

- Some CO_2 capture projects (the "low hanging fruit") will be viable under the current 45Q structure, but not enough.
- Improvements to the 45Q tax credit, such as extending the time period of the credit to 20 years and providing other support, can make retrofit of existing coal-fired power plants with CO_2 capture and addition of CO_2 capture to new NGCC plants economically viable providing significant volumes of CO_2 supply*.
- Access to capital and support for first of kind (FOAK) projects will also be important.
- Incorporating CCUS, with CO_2 EOR and with geologic storage, will provide a notably lower cost carbon management solution than without CCUS.

*Esposito, R.A., Kuuskraa, V.A., Rossman, C.G., and M.M. Corser, 2019, Reconsidering CCS in the US fossil-fuel fired electricity industry under section 45Q tax credits, Wiley Publications, Greenhouse Gases: Science and Technology, Modeling and Analysis, https://onlinelibrary.wiley.com/doi/full/10.1002/ghg.1925, 11 September 2019.

Introduction

The utilization of captured CO_2 emissions for enhanced oil recovery (EOR) provides numerous benefits:

- Increased domestic oil production, particularly once shale/tight oil production peaks,
- Safe secure storage of CO_2, with much of the oil field infrastructure already in place, and
- A source of revenues for captured CO_2 emissions.

The questions are –

- ***Is utilization of CO_2 for EOR a niche or a major opportunity?***
- ***Just how large and varied is the "prize"?***
- ***To what extent will Section 45Q tax credits boost captured CO_2 supplies for EOR?***

Capturing CO_2 from Industrial Facilities for EOR

Currently, 22 million metric tons of industrial/power plant CO_2 emissions are captured and used annually for domestic enhanced oil recovery.

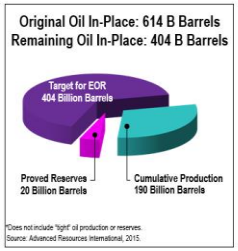
	MMMt/Yr.
• Power Plants (Petra Nova)	1.4
• Fertilizer Plants	1.7
• Hydrogen Plants	1.0
• Ethanol Plants	1.1
• Gas Processing Plants	16.8
Total	**22.0**

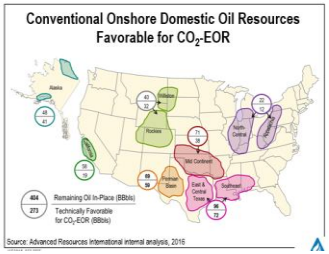
An additional 3 MMmt/yr. of CO_2 is captured at the Northern Great Plains Coal Gasification Plant and transported to Canada for EOR at the Weyburn/Midale oil fields.

The Conventional Onshore CO_2-EOR Prize

In the U.S., primary recovery and water flooding have recovered about a third of the 614 billion barrel onshore oil endowment, leaving behind 404 billion barrels.

Much of this "left behind oil", equal to 273 billion barrels, is technically favorable for CO_2-EOR and is widely distributed across the U.S.





Conventional Oil CO_2 EOR

Our assessment of the conventional oil CO_2 EOR "prize" is based on a data base of over 2,000 onshore oil reservoirs. It involves evaluating the technical and economic potential of each of these oil reservoirs using our CO_2 EOR PROPHET stream-tube simulator and our CO_2 EOR economics model.

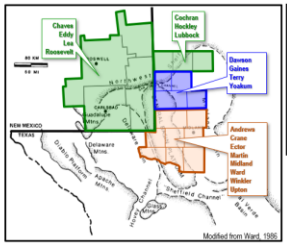
At an oil price of $60/barrel and with "best practices" technology, CO_2 EOR offers the potential for 38 billion barrels of economically viable oil recovery creating 18,300 million mt of demand (and storage) for CO_2, for a CO_2 injected to oil produced ratio of 0.48 mt per barrel.

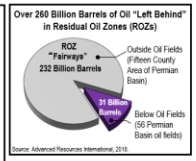
Basin/Area	OOIP Favorable for CO_2 EOR	Technically Recoverable Oil (Billion Barrels)	Technical Demand for CO_2 (Million Metric Tons)	Economically Recoverable Oil* (Billion Barrels)	Economic Demand For CO_2* (Million Metric Tons)
Lower-48 Onshore	232	72	38,400	33	16,000
Alaska	41	9	4,600	5	2,300
Total	**273**	**81**	**43,000**	**38**	**18,300**

*At an oil price of $60/B (WTI), a CO2 price of $25 per metric ton, and 15% ROR (before tax).
Source: "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.

ROZ CO_2 EOR and Demand (Storage) for CO

Advanced Resources assessment of the San Andres Fm ROZ resource in the Permian Basin of West Texas and SE New Mexico.





The "ROZ fairway" resource assessment entailed analysis of 384 logs, use of core data from 10 locations, and construction of 95 regional cross-sections.

San Andres ROZ "Fairway" CO_2 EOR

The San Andres ROZ "fairway" contains 232 billion barrels of OIP; 40 billion barrels is economically viable (at $60/B oil price), creating a demand (storage) for CO_2 of 18,400 million mt and a CO_2 injected to oil produced ratio of 0.46 per barrel.

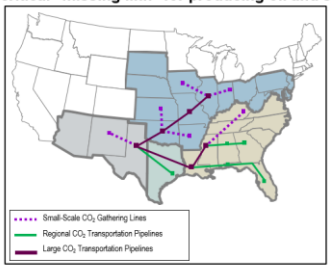
	Oil In-Place (Billion Bbls)	Technically Recoverable Oil (Billion Bbls)	Technical Demand for CO2 (Million mt)	Economically Recoverable Oil* (Billion Bbls)	Economic Demand for CO_2 (Million mt)
West Texas	**194**	**55**	**35,800**	**34**	**15,400**
• 4 County Study [1]	104	28	20,000	17	8,000
• 8 County Study [2]	71	22	12,100	15	6,300
• 3 County Study [3]	18	5	3,700	2	1,100
New Mexico	**38**	**12**	**5,800**	**6**	**3,000**
Total	**232**	**67**	**41,600**	**40**	**18,400**

*Using $60/B (WTI) oil price, a CO2 cost of $25/mt, and 10% ROR (after tax). **Totals may not add due to rounding.

1. "Defining an Overlooked Domestic Oil Resource: A Four-County Appraisal of the San Andres Residual Oil Zone (ROZ) "Fairway" of the Permian Basin" prepared by Advanced Resources International for U.S. DOE/NETL, 2016.
2. "San Andres ROZ "Fairway" Resources of the Permian Basin: An Eight-County Resource Assessment", prepared by Advanced Resources International for U.S. DOE/NETL, 2016.
3. "Permian Basin San Andres ROZ Resources Assessment: West Texas and New Mexico" prepared by Advanced Resources International for U.S. DOE/NETL, 2018.

The Missing Link: CO_2 Transportation

Lack of CO_2 transportation between sources and oil fields is the critical "missing link" for producing oil and storing CO_2 with EOR.



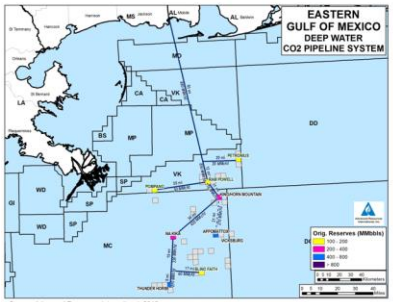
The study – **"Making Carbon a Commodity"** – proposed a comprehensive U.S. CO_2 pipeline system linking CO_2 captured from power plants with oil fields.

In Scenario #1,* the pipeline system would transport about 450 MMmt of CO_2 in Year 2040 and 950 MMmt of CO_2 in Year 2050.

*Scenario #1 represented the most aggressive CO_2 capture outlook for new coal- and gas-fueled power plants

Source: Making Carbon a Commodity: The Potential of Carbon Capture RD&D (analysis by Advanced Resources International, 2018). Sponsored by the Carbon Utilization Research Council and ClearPath Foundation (2018).

Taking CO_2 EOR to the Deepwater Offshore GOM



Advanced Resources prepared a conceptual design for a Deepwater Gulf of Mexico CO_2 pipeline system.

The Eastern GOM Deepwater CO_2 Pipeline is a 255-mile system with an initial 83-mile line delivering 880 MMcfd (17 Mmt per year).

Additional large-scale CO_2 pipeline systems are needed to serve East-Central and Central Deepwater GOM.

A Look at an Emerging CO_2 EOR "Prize"

The most recent option for productively utilizing (and storing) CO_2 is for enhancing oil recovery from shale/tight oil.

- Our compositional simulation (using GEM) for a "type" well in the central portion of the Eagle Ford Shale shows use of cyclic CO_2 injection would add 62% to oil recovery over primary methods.
- During the 12 cycles of CO_2 injection and production, an incremental 185,000 barrels of oil was produced and 840 MMcf (44,000 mt) of CO_2 was stored.
- Adding a 13th CO_2 injection cycle and closing the well enabled an additional 840 MMcf (44,000 mt) of CO_2 to be stored, providing a CO_2 stored to oil produced ratio of 9.1 Mcf/B (0.48 mt/B).

The use of cyclic CO_2 provided significantly better performance than use of cyclic dry or wet natural gas for shale/tight oil EOR.

Concluding Observations

The opportunity for productively using (and storing) CO_2 for EOR (the "size of the prize") is vast – conventional onshore and offshore oil fields, the ROZ, and shale oil formations.

With a comprehensive CO_2 pipeline system (infrastructure) and stronger incentives for CO_2 capture, in our view CO_2 EOR could use (and store) 500 million metric tons annually in the Year 2040 to 2050 time period.

While the 45Q tax credit provides a valuable first step, extending the number of years of eligibility, beyond the current 12 years, and providing support for 1st of a kind (FOAK) projects will be required.

Doing so would enable large volumes of CO_2 to be cost-effectively captured from retrofit of coal-fueled power plants and from installation of CO_2 capture on new NGCC power plants.*

*Esposito, R.A., Kuuskraa, V.A., Rossman, C.G., and M.M. Corser, 2019, Reconsidering CCS in the US fossil-fuel fired electricity industry under section 45Q tax credits, Wiley Publications, Greenhouse Gases: Science and Technology, Modeling and Analysis, https://onlinelibrary.wiley.com/doi/full/10.1002/ghg.1925, 11 September 2019.

Brad Crabtree Great Plains Institute and Carbon Capture Coalition

We have an Urgent, Time-Limited Window of Opportunity to Achieve Economywide Deployment of Carbon Capture by Midcentury

- Deployment of carbon capture to meet emissions reduction goals requires a critical mass of capture projects across industry sectors and associated pipeline infrastructure by 2030 in order to scale economywide by 2050.
- Yet, the federal 45Q tax credit expires at the end of 2023, by which time projects must begin construction.
- We are pursuing a three-part strategy in response to this challenge:
  1. Enact a broader federal policy portfolio to leverage 45Q in financing and de-risking projects, while extending the credit beyond 2023;
  2. Engage state officials and key industry, labor and NGO stakeholders to make states "carbon capture ready" by adopting policies to complement 45Q and maximize near-term deployment; and
  3. Catalyze development and expansion of new and existing regional carbon capture, transport, use and storage hubs.

CARBON CAPTURE COALITION

STATE CARBON CAPTURE WORK GROUP

REGIONAL CARBON CAPTURE DEPLOYMENT INITIATIVE

"All hands on deck" to achieve economywide deployment of carbon capture in the U.S.

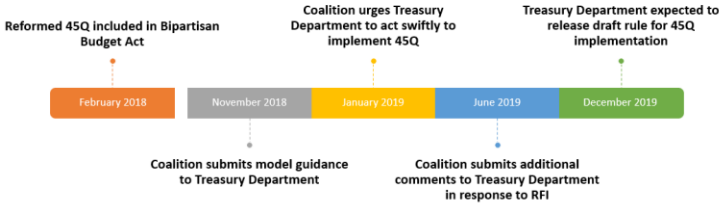
CARBON CAPTURE COALITION

Unprecedented National Coalition in U.S. Energy & Climate Policy

- ~75 energy, industrial and technology companies, unions and environmental and clean energy NGOs.
- Supports innovation and deployment across all energy resources and industry sectors.
- **Goal**: achieve economywide deployment of carbon capture from industrial facilities, power plants and ambient air to reduce carbon emissions, support domestic energy and industrial production, and create high-wage jobs.

To learn more and view our complete membership list, visit www.carboncapturecoalition.org.

Shaping U.S. Treasury's 45Q Tax Credit Guidance



Key Recommendations

Ensure flexible contractual assurance and transferability of the tax credit.

Define commence construction and continuous construction for projects to qualify.

Limit investor risk of credit recapture by establishing a safe harbor.

Provide an equivalent ISO-based monitoring and reporting program (in addition to the Subpart RR Greenhous Gas Reporting Program) for demonstrating secure geologic storage through CO_2-enhanced oil recovery.

Coalition's Federal Policy Agenda Going Forward

- Ensure effective implementation of 45Q by the U.S. Treasury to provide investment certainty and business model flexibility;
- Enact a broader portfolio of federal carbon capture policies to complement 45Q;
- Incorporate CO_2 pipeline infrastructure into national infrastructure policy; and
- Expand and diversify federal R&D, demonstration and deployment funding for carbon capture, utilization, removal and geologic storage.
- Ensure inclusion of industrial sectors in federal policy and eligibility of both CO_2 and CO emissions, where applicable.

CARBON CAPTURE COALITION

Carbon Capture Coalition's Federal Policy Blueprint

- ✓ Agenda for economywide deployment.
- ✓ Recommends full policy portfolio, similar to current support for wind, solar and other low and zero-carbon technologies.
- ✓ Consensus of Coalition's 70+ companies, unions, and NGOs.

CARBON CAPTURE COALITION

Current Legislation to Enhance and Expand on 45Q Enjoys Broad Political Support in Congress

Improvements to 45Q and other incentives

- **Extension of 45Q commence construction window (introduced):**
  - House Carbon Capture and Sequestration Extension Act would extend 45Q by one year through 2024.
  - Five majority cosponsors and included in House Ways and Means majority energy tax discussion draft. Coalition requesting parity with 5-year extensions proposed for wind, solar and other technologies. Exploring Senate companion.
- **Direct pay or enhanced transferability to increase monetization of 45Q:**
  - House Ways and Means majority discussion draft proposes direct pay provision for renewable electricity tax credits. Coalition requesting same treatment for 45Q.
  - Senate legislation anticipated to provide enhanced transferability for 45Q.
- **Carbon Capture Modernization Act (introduced):**
  - Corrects design flaws in Section 48A tax credit to enable carbon capture retrofits of existing coal power plants.

Current Legislative Priorities Cont.

Additional incentives to complement 45Q:

- **Carbon Capture Improvement Act (introduced)**
  - Authorizes use of tax-exempt private activity bonds in financing carbon capture and utilization projects.
- **Financing Our Energy Future Act (introduced)**
  - Makes carbon capture and utilization projects eligible for master limited partnerships (tax advantage of partnerships, with ability to raise equity in public markets).
  - Included in House Ways and Means majority energy tax discussion draft.

Current Legislative Priorities cont.

Expanding and retooling federal R&D:

- **USE IT Act (passed U.S. Senate)**
  - Supports demonstration of direct air capture and R&D for CO_2 and CO utilization; and
  - Facilitates planning, siting and permitting of CO_2 transport infrastructure.
- **Senate EFFECT & LEADING Acts/House Fossil Energy R&D Act (reported out of House/Senate committees)**
  - Expands and retools U.S. DOE research, development, demonstration and deployment (RDD&D) objectives and programs for carbon capture, utilization, removal and storage.

Clean Industrial Technology Act (reported out of House/Senate committees)

- Establishes Industrial Emissions Reduction Technology Development Program for innovative technologies, including carbon capture.

INVEST CO_2 Act: First-Ever Federal CO_2 Transport Infrastructure Financing Bill Introduced in October

- Rep. Cheri Bustos (D-IL) introduced the **Investing in Energy Systems for the Transport of CO_2 Act of 2019 (INVEST CO_2 Act).**
- Advances key recommendations of the Carbon Capture Coalition's Federal Policy Blueprint:
  - Low-interest federal loans to finance extra pipeline capacity and realize economies of scale;
  - Federally-supported large-volume, long-distance CO_2 trunk lines to support development of key regional hubs; and
  - Encourages state and local governments to designate anthropogenic CO_2 pipelines as "pollution control devices" to enable tax abatement.
- Legislation aims to help enable state/regional efforts to advance specific infrastructure projects.

Integrated Federal-State Policy & Regional Hub Development are Key to Success

Federal
45Q + complementary policy portfolio

+

Regional
Hub infrastructure buildout
Stakeholder engagement

+

State
Tax optimization
Regulatory Policies
Financial Incentives

=

Economywide Deployment of Carbon Capture

Regional Deployment Initiatives: Where We are in the Process

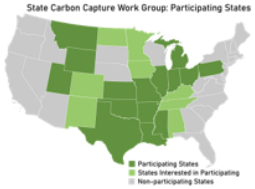
Phase I	Phase II	Phase III
Preliminary Analysis (Jan-Sep 2018)	Convening State Officials and Stakeholders (October 2018)	Supporting State Policy Development and Projects (Underway)
Mapping industrial facilities, power plants and CO_2 storage opportunities, initial cost analysis, and preliminary pipeline modeling.	Launched Initiatives in Columbus, OH and Salt Lake City, UT.	Identify candidate projects and state policies to complement 45Q credit. Prepare for 2020 state legislative sessions. Cooperate regionally on CO_2 transport infrastructure and hub development.

REGIONAL CARBON CAPTURE DEPLOYMENT INITIATIVE

https://carboncaptureready.betterenergy.org/

STATE CARBON CAPTURE WORK GROUP

- Formed in 2015 by then Governor Mead (R-WY) and Governor Bullock (D-MT).
- 15 states participating; actively recruiting additional states.
- Work Group launched Midwestern and Western Regional Deployment Initiatives in early 2018.
- **Goal**: Help states become "carbon capture ready" to leverage 45Q through state policy development and planning to support carbon capture and CO_2 project deployment.

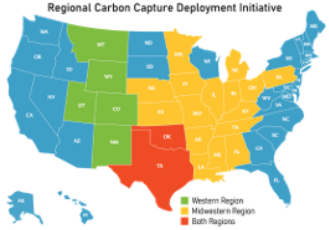


EPA GHGRP & eGRID US DOE EIA ABB / Energy Velocity	**CO_2 Supply** Industrial & Power	
Stanford NETL, IEA National Petroleum Council	**Capture Costs**	
Advanced Resources International	**EOR** Potential Demand	**SimCCS** Los Alamos
NETL & USGS Los Alamos National Lab Indiana University Ohio State	**Saline** Storage Potential SCO2T	
NETL Los Alamos Princeton Industry Consulting	**Pipeline Costs**	

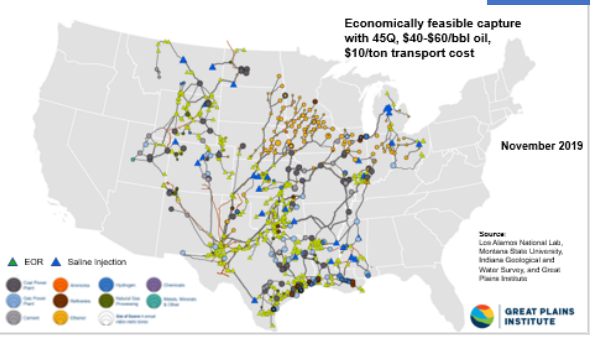
Economic retrofit at break even – **identify feasible projects**, some with additional state policy support

Regional scale transport infrastructure to **maximize capacity** with financing support

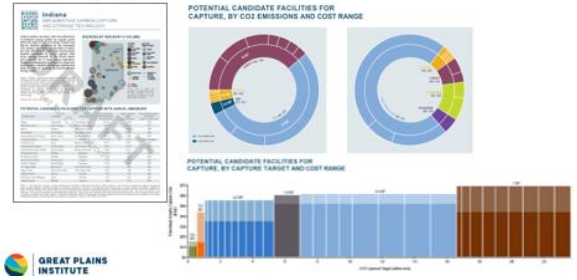
Regional Deployment Initiatives: Western & Midwest Regions



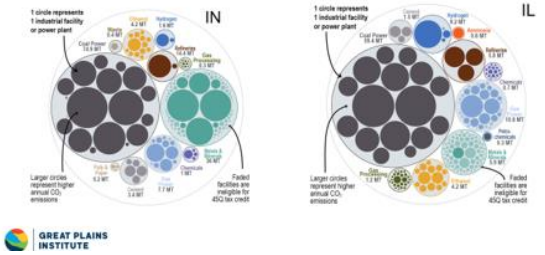
REGIONAL CARBON CAPTURE DEPLOYMENT INITIATIVE



CO2 Deployment Fact Sheets: Tailored to Each State



CO2 Deployment Fact Sheets: Tailored to Each State



Brad Crabtree
Vice President, Carbon Management
Great Plains Institute

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Fred Eames Partner Hunton-Andrews-Kurth LLP

HUNTON ANDREWS KURTH

Federal Issues and Carbon Capture Utilization and Storage

Subtitle

Fred Eames
Partner, Hunton Andrews Kurth LLP
December 9, 2019

Hunton Andrews Kurth LLP

- Global law firm created by the 2018 merger of Hunton & Williams and Andrews Kurth Kenyon, creating a one-stop shop for the energy marketplace
- More than 1000 lawyers in 20 offices worldwide
- Full-service capabilities, organized around teams and practices
- We have represented:
  - 90% of the Fortune 10
  - 70% of the Fortune 50
  - 60% of the Fortune 100
- Emphasis on client service and responsiveness
  - BTI Client Service A-Team member for 16 straight years (annual survey of Fortune 1000 GCs)
- Key practice areas: project finance, energy tax credits, environmental and regulatory (air, water, solid waste, infrastructure), public policy
- Preeminent energy and environmental practice and full-service private

Personal Background

- Partner, Washington, D.C. office
- 21 years in private practice
- Counsel, House Energy & Commerce (energy and environmental issues)
- Formed and led two CCUS policy groups:
  - Energy Advance Center, 2018 –
  - CCS Alliance, 2008 - 15
- Member, National Coal Council
- Lead Author, 2015 National Coal Council report, "Leveling the Playing Field: Policy Parity for Carbon Capture and Storage Technologies"

How CO2-EOR is Viewed in Washington

Opportunity

- Broader center emerging in support of CO_2-EOR
- Bipartisan willingness to provide policy support
- Increasing recognition of need for carbon storage to meet climate goals

Challenge

- More vocal opposition to fossil fuels developing in parts of society
- Climate change increasingly viewed as an "existential" threat
- CO2-EOR = more oil = more CO2

What about energy security, geopolitical significance?

Democratic Presidential Candidates on Climate Change and Fossil Fuels

Candidate	Ban Fossil Exports	Ban Fracking	Green New Deal	Clean Energy Standard	CO2 Cost and Pay Fees	Eliminate Fossil Subsidies	Public Lands Fossil Moratorium	Other
Joe Biden	Yes	Increase fracking regulation	Yes	100% clean energy by 2050	Reverse tax cuts to corporations.	Yes	Yes	Net zero carbon emissions by 2050 Carbon price
Elizabeth Warren	Yes	Yes Executive Order on Day 1	Yes	100% zero emission electricity generation by 2035	Reverse tax cuts to the wealthy and corporations.	Yes	Yes Executive Order on Day 1	Net zero carbon emissions by 2050 Carbon price Zero emissions for all buses, passenger vehicles and medium-duty trucks by 2030
Bernie Sanders	Yes	Yes "Safe fracking is, like clean coal, pure fiction"	Yes	100% renewable by 2030 Electricity, virtually two other 100% except cooperative cuts	Make the fossil fuel industry pay for their pollution through litigation, fees, and taxes	Yes	Yes	Net zero carbon emissions by 2050 "Fossil fuel executives should be criminally prosecuted for the misbehavior they have knowingly caused." 100% zero emission transportation by 2030
Pete Buttigieg		Ban new fracking and work to eliminate existing fracking	Yes	Double clean electricity by 2025 Zero emissions in electricity generation by 2035	Federal investments that will trigger private, state and local investment	Yes	Yes	Net zero emissions by 2050 Carbon price Net zero emissions from industrial vehicles by 2040

Why does it matter?

- Investors are forcing action to address climate change
  - Edelman's latest Trust Barometer — a subset of the larger survey that the giant P.R. company puts out each January — polled 600 institutional investors in six countries, who collectively manage more than $9 trillion.
  - 84% said that "maximizing shareholder returns can no longer be the primary goal of the corporation." – Axios, December 6, 2019
- Companies increasingly are making decisions based on climate impacts
  - ESG investing estimated at $20 trillion, or one-quarter of professionally managed assets
- "Low carbon oil" is good. The risk: "no oil" becomes better.
  - European Investment Bank to end all fossil project funding in two years

And these are developments under the Trump Administration

Policy Outrunning Reality

Democratic Deputy Staff Director, House Select Committee on the Climate Crisis

"Just in the last couple of years, so many states have come forward with 100 percent clean energy goals, both mandates and aspirations. That's been huge and has helped socialize and normalize that goal on Capitol Hill in a way that even six months ago was not there.

Cassady said she "can't emphasize enough" how important that such a target "becomes just commonly accepted."

- Atlantic Council Presentation
November 20, 2019

CO2-EOR Policy Issues

- Incentives
- Infrastructure
- Regulatory issues
- Climate issues

Incentives

- 45Q tax credit for geologic storage of anthropogenic CO2
  - Major update enacted in February 2018. Key changes:
    - EOR credit rises to $35/ton by 2026; indexed to inflation after that
    - 12 year credit period
    - Enhanced transferability
    - Available for use (EOR), storage, and now "utilization" of CO2
  - Guidance expected soon
    - Expected to cover partnership structures, commencement of construction
  - Regulations expected early next year
  - Key issues for CO2-EOR
    - Secure geological storage
    - Commencement of construction
    - "Otherwise emitted to the atmosphere"
    - Recapture
    - Partnership structures
    - Transferability

Incentives (cont'd)

- Other incentives
  - DOE RD&D – EFFECT Act
    - Increase funding for CCUS research, development and deployment
    - Direct funding toward large large-scale pilots and commercial demonstration
    - Extend research to natural gas
  - Master limited partnerships
  - Private activity bonds
  - Contracts for differences

Infrastructure

Can federal policy help get CO2 from new sources to the oil field?

- USE IT Act – S. 383
  - Streamlined infrastructure permitting for CO2 pipelines
- Investing in Energy Systems for the Transport of CO2 Act – H.R. 4905
  - DOT to provide credit instruments for common carrier CO2 pipelines
  - Covers trunk pipelines and feeder pipelines, and increased diameter
  - Not more than one project per census region (four regions)
  - Up to 80% of project cost; up to 35 years maturity
  - Loan guarantees
- Infrastructure addressed in upcoming NPC report
- Federal eminent domain authority

Regulatory Issues

- USE IT Act
- NEPA reform
- NSR reform
- Class VI issues (CCS, not CO_2-EOR)
- Energy regulatory issues – resilience and fuel security

Climate Issues

- Green New Deal
- House Democrats climate package

Climate action currently driven primarily at the international and private sector levels

We'll always have Paris . . . .

U.S. CO2 emissions have decreased more than the next 12 countries combined

National Petroleum Council Report

September 21, 2017 request from Secretary Perry to

define potential pathways, including research and development, regulatory, and policy options, for integrating CCUS at scale into the energy and industrial marketplace, with specific emphasis on the petroleum industry. This study should address the entire CCUS value chain from capture through use and/or storage and consider technologies applicable to power generation, industrial processes, and enhanced oil recovery, as well as different fuel types or energy sources such as coal, oil, and natural gas.

Questions to be addressed

- Global future energy demand outlook and environmental benefits of CCUS
- R&D, technology, and infrastructure barriers to deploying CCUS at scale
- Definition of success
- Actions needed to establish an economic framework to stimulate investment
- Regulatory, legal, liability, or other issues to be addressed to progress commercial investment

NPC meeting to approve report on December 12

Thank you

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Mark Coalmer OGCI CCUS Projects

Practical action for a lower carbon footprint

Mark Coalmer

December 2019

Oil and Gas Climate Initiative (OGCI)

THE INITIATIVE : LOWER CARBON VIA COLLECTIVE ACTION & PARTNERSHIPS

CLIMATE INVESTMENTS : LOWER CARBON VIA INVESTMENTS

INVEST in innovative low-carbon technologies and solutions.

SUPPORT our portfolio companies with access to customers and deployment.

COLLABORATE with OGCI members and other stakeholders to gain speed and global reach.

The climate challenge and CI focus

50 GIGATONNES MANMADE GREENHOUSE GASES (GHG)

ENERGY & INDUSTRIAL ~3/4 OF MANMADE GHGs

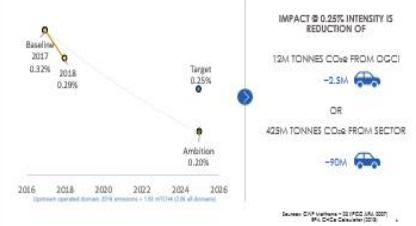
CLIMATE INVESTMENTS ($1B+)

- Reduce methane emissions in oil & gas
- Reduce carbon dioxide emissions in energy & industrial
- Recycle & store carbon dioxide in energy & industrial (CCUS)

Reduce methane emissions

Investments to reduce methane emissions

OGCI collective methane intensity target



IMPACT @ 0.25% INTENSITY IS REDUCTION OF

12M TONNES CO_2e FROM OGCI

~2.5M

OR

425M TONNES CO_2e FROM SECTOR

~90M

Reduce carbon dioxide emissions

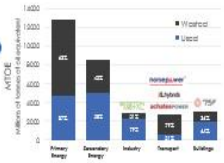
Investments to reduce CO_2 through energy efficiency

CHALLENGE

2/3

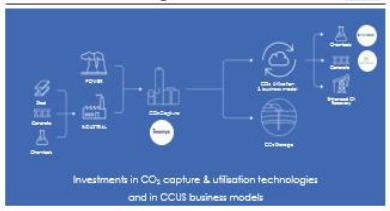
> 66% primary energy is currently wasted

ENERGY EFFICIENCY: THE WORLD IN 2016 (40 % ABATEMENT REQUIRED TO ~2ºC)



Recycle & store carbon dioxide (Carbon Capture, Utilisation & Storage)

Investments in CCUS technologies



CI CCUS project investments: prove business models

Illustrative CCUS projects proximate to CO2 storage or EOR offtake offer the most attractive opportunities with expected unlevered IRRs of up to ~25%

CI CCUS project investments: prove business models

UK – TEESSIDE PROJECT

- Greenfield project: power & industrial
- Potential impact 3-5 Mtpa
- Start date ~ mid-2020's
- Policy structure: hybrid
- Partners : 6 OGCI companies

USA – WABASH VALLEY

- Brownfield project: industrial
- Potential impact 1.5 Mtpa
- Start date ~ 2023
- Policy structure: 45Q + state level
- Partners: developers + DOE

Carbon Capture, Utilisation & Storage Kickstarter

DEVELOP 5 CCUS HUBS VIA PRIVATE & PUBLIC PARTNERSHIPS

GOAL TO KICKSTART A CCUS MARKET

CCUS Considerations

- "Everyone" has a goal of carbon neutrality by 2050
- Regulatory frameworks are improving
- Economics work for SOME projects now
- Continued innovation is needed to improve economics
- We have a choice, or no choice

Thank you

Mark Coalmer

www.oilandgasclimateinitiative.com

Barry Worthington CEO United States Energy Association - USEA

- International community shifting the “goal posts” in GHG emissions reductions from 2050 to 2030
- The reality of carbon neutral can be achieved while still using fossil fuels rather than “Leave it in the Ground”…
- Important consideration that the upcoming younger workforce and its ideals are replacing the current older workforce….
- Institutional pressures on their holdings are very real and global…
- The US leads the world in overall emissions reductions, technology development and deployment but little global recognition, more focused on the US leaving the Paris Accords…

- www.usea.org

USEA
United States Energy Association

John Hamling EERC/UND

EERC | UND UNIVERSITY OF NORTH DAKOTA

Critical Challenges. Practical Solutions.

EERC | UND UNIVERSITY OF NORTH DAKOTA

Energy & Environmental Research Center (EERC)

CARBON CAPTURE, UTILIZATION, AND STORAGE

REGIONAL UPDATE FOR THE WILLISTON BASIN

25th Annual CO_2 Conference
Midland, Texas
December 9, 2019

John Hamling
Assistant Director, Integrated Projects

REGIONAL POTENTIAL

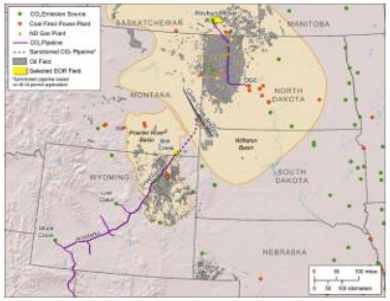
A Prolific Oil-Producing Region in North America

- Conventional
- Unconventional
- Stacked horizons
- Residual oil zones (ROZs)?

Abundant Anthropogenic CO_2 Sources Proximal to Enhanced Oil Recovery (EOR) and Storage Opportunities

Growing CO_2 Transportation Network

Massive CO_2 Storage Potential in Deep Saline Formations



BAKKEN EOR SIZE OF THE PRIZE

Original Oil in Place (OOIP) Estimates

300 Bbbl
(Flannery and Kraus, 2006)

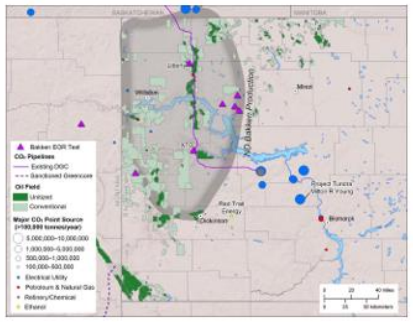
900 Bbbl
(Continental Resources, 2011)

Technically Recoverable Reserve Estimates (primary recovery)

7.4 Bbbl
(USGS, 2013)

24 Bbbl
(Continental Resource, 2011)

Business as usual gets about 15 billion barrels.



ENORMOUS OPPORTUNITY

86 conventional unitized fields:

- 280 million to 630 million bbl of incremental oil
- 47 million to 283 million metric tons of CO_2 needed

200+ conventional fields

- >1 Bbbl of incremental oil
- >358 million metric tons of CO_2 needed

Conventional + Bakken Petroleum System:

- 4 Bbbl–7.6 Bbbl of incremental oil
- 2 Btons–3.8 Btons of CO_2 needed

...or more

INCENTIVES

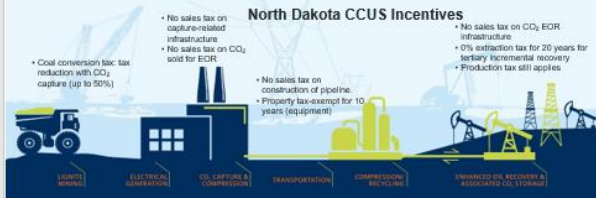
West Coast LCFS

- Credits trading for $136 to $192 per ton.
- Stacked with 45Q

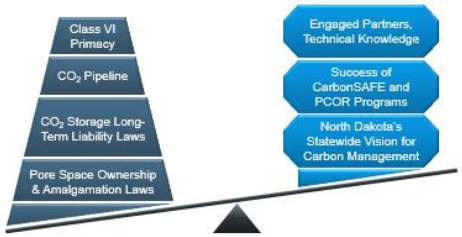
45Q Tax Credits

- Projects beginning construction before January 1, 2024, can claim credits for 12 years after operations begin.
- Tax credits claimed by the taxpayer capturing the emissions or transferred to operators of CO_2 EOR) projects.
- Tax credit for CO_2 stored in a qualified EOR project is $15.29/tonne; increases annually to $35/tonne in 2026.
- Tax credit for CO_2 stored in a saline formation is $25.70/tonne; increases annually to $50/tonne in 2026.

North Dakota CCUS Incentives



NORTH DAKOTA'S LEVERAGE



Accomplishments

- ✓Established technical feasibility
  - Approx. 40% net CO_2 emissions reduction
- ✓Established economic viability
  - Via LCFS programs, federal incentives, etc.
- ✓CO_2 capture design package
- ✓Near-surface baseline sampling
- ✓3-D seismic survey and interpretation
- ✓Characterization and test design
- ✓Permit to drill stratigraphic test well
- ✓Stakeholder and community outreach

Next Steps

Stratigraphic test well

- Drill, core, log, test, and install downhole monitoring
- Update modeling and implementation plans

Class VI storage facility permit and LCFS pathway

Construct and operate CCUS site

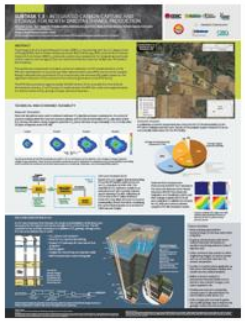
RED TRAIL ENERGY, LLC

North Dakota Ethanol Production

Reduced Carbon Intensity of North Dakota Ethanol Production Through Geologic CO_2 Storage

Incentive Programs

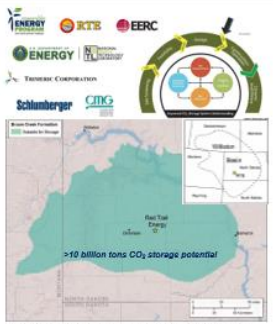
- Low-carbon fuel standard (LCFS) programs (~$200/tonne)
- 45Q ($50/tonne)



RED TRAIL ENERGY, LLC

North Dakota Ethanol Production

- Carbon capture
  - 180,000 tons of CO_2 per year from fermentation
  - Nearly pure CO_2 stream
- Carbon storage
  - Broom Creek Formation
  - 6400 ft directly below Red Trail Energy facility, ~300 ft thick



Operated by Minnkota Power Cooperative, the Young Station is a mine-mouth generating station that uses lignite coal supplied from the adjacent BNI Coal mine. Unit 2, a 435-megawatt unit that began commercial operation in 1977, is the target for Project Tundra.

Project Tundra is in the advanced research and design phase. If the project moves ahead, construction will commence in 2022-2023

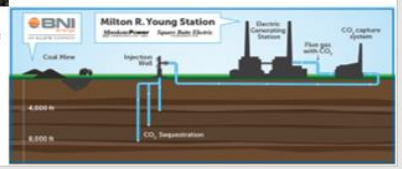
Precommercial:

Front-end engineering and design (FEED) study in procurement.

90% postcombustion CO_2 capture (~4 million tons per year).

Preparing to pursue federal and state permits required to build CO_2 capture facility and store CO_2 in deep geologic formations.

Exploring ND EOR opportunities.



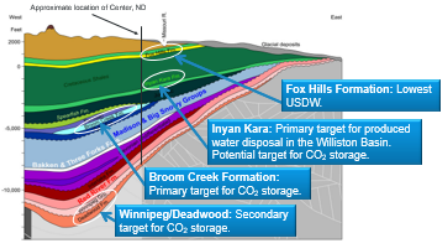
NORTH DAKOTA CarbonSAFE

Schlumberger

EERC | UND UNIVERSITY OF NORTH DAKOTA

Critical Challenges. Practical Solutions.

CARBONSAFE ZONES OF FOCUS

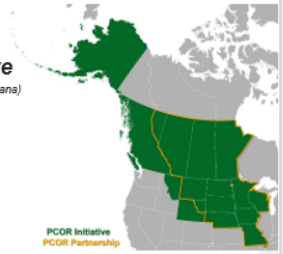


PCOR INITIATIVE

2019–2024: PCOR Initiative

(Expanded to include Alaska, Wyoming, and all of Montana)

2007–2019: PCOR Partnership Phase III
2005–2008: PCOR Partnership Phase II
2003–2005: PCOR Partnership Phase I



PCOR INITIATIVE

2019–2024

Address key technical challenges by advancing critical knowledge/capabilities; facilitate data collection, sharing, analysis, and collaboration; evaluate regional infrastructure challenges and needs; promote regional technology transfer.

Goal:

Identify and address regional storage and transport challenges facing commercial CCUS deployment.

Vision:

Provide the premier regional forum to promote CCUS infrastructure and accelerate CCUS deployment.

ENGAGED PARTNERS

NORTH DAKOTA BRINE EXTRACTION AND STORAGE TEST

GEOLOGIC CO_2 STORAGE

CONSIDERATIONS FOR COMMERCIAL PROJECTS

- Buoyant fluid
- Large volumes = large footprint
- Transportation
- Access to pore space
  - Leasing, unitization/amalgamation, trespass
- Regulatory compliance
- Assuring permanence for incentives or credits
  - Conformance and storage efficiency

Because of a host of technical, social, regulatory, environmental, and economic factors, brine disposal tends to be more accessible and generally quicker, easier, and less costly to implement compared to dedicated CO_2 storage.

ACTIVE RESERVOIR MANAGEMENT (ARM)

TWO COMPLEMENTARY COMPONENTS

ARM Test

- Reduce stress on sealing formation
- Geosteer injected fluids
- Divert pressure from leakage pathways
- Divert pressure from CO_2 plume
- Reduce AOR and amalgamated area
- Improve injectivity, capacity, and storage efficiency
- Validate monitoring techniques, and forecast model capabilities

Brine Treatment Test Bed

- Alternate source of water
- Reduced disposal volumes
- Salable products for beneficial use

Brine extraction can enable dedicated CO_2 storage and improve the geologic CO_2 storage potential of a site.

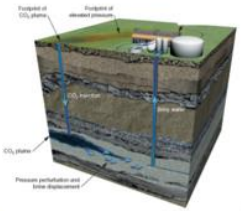


Illustration modified from Lawrence Livermore National Laboratory https://str.llnl.gov/Dec10/aines.html

ACCOMPLISHMENTS

ACTIVE RESERVOIR MANAGEMENT

ACCOMPLISHMENTS

BRINE TREATMENT DEVELOPMENT FACILITY

EERC | UND UNIVERSITY OF NORTH DAKOTA

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Luncheon Keynote Speaker
Darrell Ricketson
Vice President and Chief Operating Officer
Kinder Morgan CO_2

KINDER MORGAN

CO2 - EOR Carbon Management Workshop

Darrell D. Richardson
Chief Operating Officer
Kinder Morgan CO2 Company

December 9, 2019

Outline

- Overview of Kinder Morgan
- CO_2 Source and Transportation Assets
- Development Planning, Costs, Compliance
- Tall Cotton
- People Needs
- KM Outlook and Support for CCUS

- Natural Gas Transmission
- Products Pipelines
- Terminals
- CO_2

KINDER MORGAN

OUR VISION

Delivering Energy to Improve Lives and Create a Better World

Kinder Morgan: Leader in North American Energy Infrastructure

KINDER MORGAN

Unparalleled and irreplaceable asset footprint built over decades

Largest natural gas transmission network
- ~70,000 miles of natural gas pipelines
- ~207 bcf/d of working storage capacity
- Connected to every important U.S. natural gas resource play and key demand centers
- More ~40% of natural gas consumed in the U.S.

Largest independent transporter of refined products
- Transport ~1.7 million b/d of refined products
- ~9,800 miles of refined products pipelines
- ~5,600 miles of other liquids pipelines (crude and natural gas liquids)

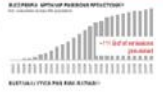
Largest independent terminal operator
- ~151 terminals
- ~76 (mmbbl) volume

Largest transporter of CO_2
- Transport ~1.2 bcf/d of CO_2

Committed to Being a Good Corporate Citizen

KINDER MORGAN

Long-standing commitment to safe operations and reduction of methane emissions



#2 out of 163 Refiners and Pipelines (Industry Group)

#2 out of 91 Oil & Gas Storage and Transportation (Industry)

CO_2 Segment Overview

KINDER MORGAN

World class, fully-integrated assets | CO_2 source to crude oil production and takeaway in the Permian Basin

CO2 & TRANSPORT

EOR OIL PROD

CO_2 Source Assets

KINDER MORGAN

- CO_2 deliveries kicked off in 1984

Kinder Morgan CO_2 Company

KINDER MORGAN

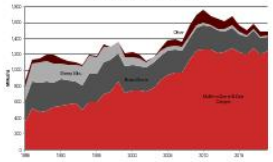
- Acquired Shell CO_2 in 2000
- Added EOR targets
  - SACROC - first commercial CO2 flood started by Chevron in 1972
  - Yates Field – various EOR processes employed
  - Tall Cotton – first greenfield ROZ development
- Overall: 1.3 BCFD source CO_2, 22,000 BOPD, 21,000 BNGLPD, 140,000 BOPD transport, 1.6 BCFD of recycle CO_2

CO_2 Deliveries to Permian Basin

KINDER MORGAN

- CO_2 supply to the Permian over past 20 years demonstrates strong demand through oil price cycles

Permian Basin CO_2 Deliveries



CO_2 Development and Market

KINDER MORGAN

- **Continued development of CO_2 sources needed to satisfy customer demand for existing and future floods**
  - Supply is available
  - Development offsets declines and adds to contract growth
  - Costs are increasing for wellbores, infrastructure
  - Regulations
- **Structure of CO2 contracts**
  - Indexed to oil price
  - Designed to cover costs

Capital Discipline

KINDER MORGAN

- **Development spend optimized based on contractual commitments**
  - Long term contracts needed to support these commitments
  - Short term flexibility limited
  - Important for good communications with customers
- **Development Capital from 2000-2019**
  - $7.8 B total segment
  - $1.5 B for Source and Transportation

CO_2 Source Development

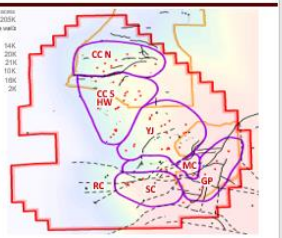
KINDER MORGAN

McElmo Dome – 203,000 acres

McElmo Dome Drainage Areas

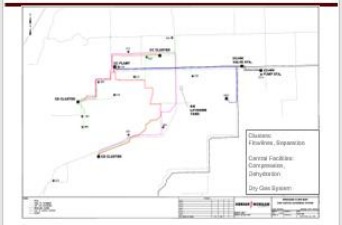
KINDER MORGAN

Total Unit	203K
	79 active wells
CC N	14K
HW & CC S	20K
Yellow Jacket	21K
Sand Canyon	10K
Goodman Pt	18K
Mogul	2K



Cow Canyon Gathering System

KINDER MORGAN



CO_2 Source Development

KINDER MORGAN

- **Regulatory process requires significant planning time**
  - 2-4 year permitting process
  - Local, state, federal agencies
  - Coordinated efforts for proper alignment
  - Agency and public meetings
  - Requirements vary by impact area

EOR Development

KINDER MORGAN

- **Tall Cotton - Greenfield ROZ Development**
  - Good pay packages
  - Complex geology
  - Processing rate and sweep challenges
  - More data and understanding to optimize future development
- **ROZ Industry Development**
  - Significant oil targets
  - Future target with CCUS

Outlook and Staying Competitive

KINDER MORGAN

- **Economics for ROZ and conventional CO_2 Floods**
  - CAPEX and operating costs typically higher
  - Good subsurface understanding
  - Commitment for safe and reliable operations
  - IRR better where main pay exists, lower royalties, efficiencies
- **Future will drive more CO_2 capture which is good for EOR**
- **45Q will help close gap of economic hurdles but more needed**
- **Helium where viable helps economics**

Outlook and Staying Competitive

KINDER MORGAN

- **We need to continue developing and attracting CO2 – EOR expertise**
- **Specialized industry**
  - Great ideas, ingenuity, work ethic driving success
  - Complex problem solving
  - Diverse disciplines needed in our business
- **Competition with high profile plays and negative press**

Outlook and Staying Competitive

KINDER MORGAN

- **Industry environmental responsibility and sustainability compliments CCUS growth**
- **Kinder Morgan natural fit to support the future of CCUS**
- ***Technology, ingenuity of people needed to crack the code***

..... along with this Workshop and Conference

KINDER MORGAN

Thank You !

Questions ?

December 9, 2019

Nigel Jenvey - Charles McConnell & Moderator Michael Moore - EWSA

Gaffney, Cline & Associates

UNIVERSITY of HOUSTON

Public Pressures, CSR-ESG and Carbon Management

17th Annual EOR Carbon Management Conference

9th Dec , 2019

Nigel Jenvey
Vice President
Global Head of Carbon Management
Gaffney, Cline & Associates

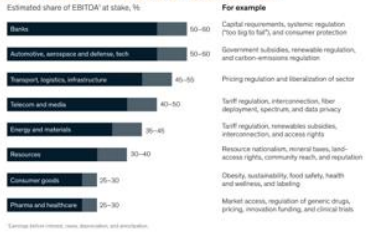
Charles McConnell
Executive Director
Center for Carbon Management and Energy Sustainability
University of Houston

CSR - from the billboards of activists to the boardrooms of the largest companies

Corporate Social Responsibility

CSR - The value to a company

A large share of corporate profits are at stake from societal views



ESG – A new fiduciary reporting mechanism

Environmental, Social and Governance

E = environmental

Company energy and resource needs, waste discharge and the consequences for ecosystem as a result. Not least, this encompasses carbon emissions and climate change. Every company uses energy and resources; every company affects, and is affected by, the environment.

S = social

Company relationships and reputation with people and institutions in the communities where they do business. This includes labor relations and diversity and inclusion. Every company operates within a broader, diverse society.

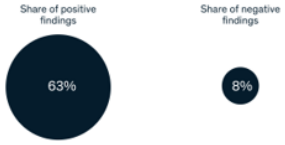
G = governance

Company practices, controls, and procedures to govern itself, make effective decisions, comply with the law, and meet the needs of external stakeholders. Every company, which is itself a legal creation, requires governance.

ESG - The value to an investor

ESG-oriented investing now tops $30 trillion and has positive results for shareholders

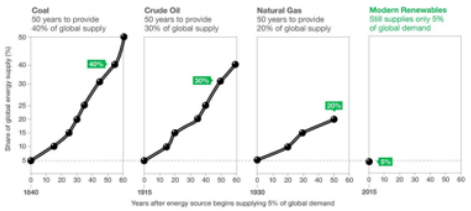
Results of >2,000 studies on the impact of ESG propositions on equity returns



Source: Gunnar Friede et al., "ESG and financial performance: Aggregated evidence from more than 2000 empirical studies," Journal of Sustainable Finance & Investment, October 2015, Volume 5, Number 4, pp. 210–33; Deutsche Asset & Wealth Management Investment; McKinsey analysis

Energy Transitions have historically taken a long (long) time

It has taken decades for major energy sources to provide a significant share of global supply



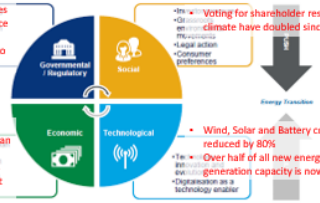
The current energy transition has different drivers

Changes in public opinion and intensifying investor pressure are new phenomena in today's society

The current energy transition has different drivers

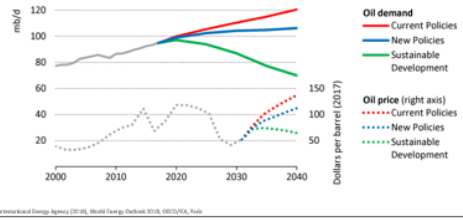
Changes in public opinion and intensifying investor pressure are new phenomena in today's society

- Climate change laws and policies have doubled every 5 years since the Kyoto Protocol
- $3 trillion public investment into renewable technologies
- For the last few years more capital is spent on electricity than oil and gas supply
- Increasing debt to equity ratios and now over $1 trillion of debt in oil and gas supply
- Voting for shareholder resolutions on climate have doubled since 2015
- Wind, Solar and Battery costs have reduced by 80%
- Over half of all new energy-generation capacity is now renewable



Sustainable Investment Assessments – Market Impacts

Impacts on Demand (commodity prices) and Supply (production costs) need to be understood



Sustainable Investment Assessments – Central Banks

Central Banks are looking at the impacts on the risk to investments and ensuring a stable energy transition

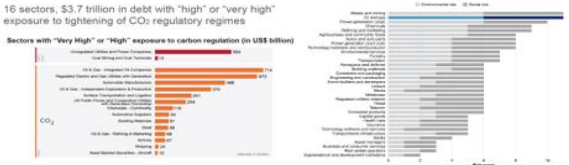
Sustainable Investment Assessments – Investment Management Companies

Investors are asking for ESG reports and assessment of climate related risks to investments

Sustainable Investment Assessments - Credit Ratings Agencies

Assessment of ESG risks to investments

16 sectors, $3.7 trillion in debt with "high" or "very high" exposure to tightening of CO_2 regulatory regimes



Sustainable Investment Assessments - Oil and Gas companies

Large Independent O&G companies are assessing and managing portfolio risks

Repsol to cut carbon emissions to net zero by 2050 at $5.3 billion cost

REUTERS

Source: Reuters, 2019

MEETING THE AMBITION: HOW SHELL COULD CHANGE

An infographic showing how Shell could change in the future

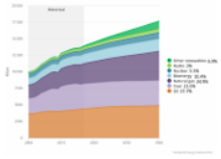
Source: Shell (2018)

The Dual Challenge

Gaffney, Cline & Associates

The dual challenge: More energy, to lift people out of poverty

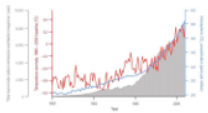
The IEA projects >25% increase in energy demand to 2040



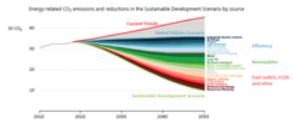
The correlation between rising living standards and increased energy use is well established

The dual challenge: Less GHG emissions, to combat the impacts of climate change

Global surface temperatures have risen sharply since the industrial revolution



Deployment of low carbon technology is vital to achieve a sustainable pathway



The National Petroleum Council CCUS Study

Gaffney, Cline & Associates

Preview of NPC Study on CCUS

Secretary Perry's request asked five key questions

The Secretary of Energy

1. What are **U.S. and global future energy demand outlooks**, and the environmental benefits from the application of CCUS technologies?
2. What **R&D, technology, infrastructure, and economic barriers must be overcome** to deploy CCUS at scale?
3. How should **success be defined**?
4. What actions can be taken to **establish a framework that guides public policy and stimulates private-sector investment** to advance the development and deployment of CCUS?
5. What **regulatory, legal, liability, or other issues should be addressed** to progress CCUS investment and to enable U.S. to be global technology leaders?

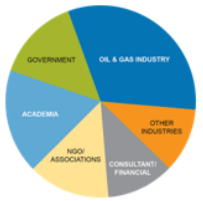
Rick Perry

Define pathways leading to CCUS deployment at scale

The study will:

- Establish **importance of CCUS** in the U.S.
- Evaluate **CCUS supply chain** including drivers of U.S. project success and costs of deployment across all sectors and fuel types
- Address **variety of factors** (e.g., economics, policy, technology, etc.)
- Focus primarily **on accelerating CCUS deployment within the U.S.** while learning from and considering implications for rest of the world
- Deliver **prioritized, actionable recommendations** across three phases of CCUS deployment
- Provide a **roadmap for deployment** for U.S. government and industry

Participants offer diverse, cross-industry perspectives



- The CSC has membership of 21 individuals representing upstream and downstream oil & gas, LNG, biofuels, power, EPC, NGO, academia and state and federal governments.
- The overall study team is currently composed of over 300 participants from more than 110 different organizations and includes 17 international members.
- National Coal Council participation is represented through overlap of 21 organizations.

U.S. leads in CCUS deployment

The United States has become the world leader in CCUS with:

- 40+ years of successful EOR experience
- Ten of 19 industrial scale projects, 80% of the world's capacity
- Over 5,000 miles of CO_2 pipeline
- 20+ years of DOE leadership and support
  - $4.5bn in RD&D programs
  - Over 20 million tonnes CO_2 stored
  - Public-private partnerships
- World-leading policy support (e.g., 45Q)
- Established regulatory framework

Extending U.S. leadership position

The United States will continue to lead by:

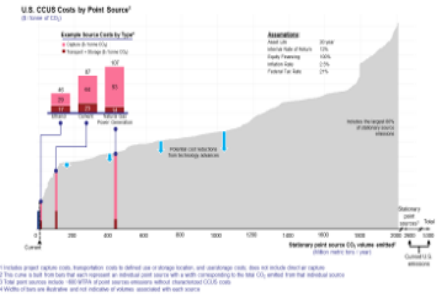
- Increasing research and capability
- Leveraging vast onshore and offshore storage potential
- Engaging stakeholders to increase understanding and confidence in CCUS
- Expanding deployment across all sources and industries

Differential feature of NPC Study – U.S. CCUS cost curve

Study has assessed the costs to capture, transport and store the largest 80% (~2Gt) of U.S. stationary sources:

- Cost to capture, transport, and store one tonne of CO_2 plotted against the volume of CO_2 abatement possible
- Source, industry and location specific
- Transparent assumptions, leveraging existing studies combined with industry experience
- Identifies level of value (incentives, revenue, etc.) necessary to enable deployment
- Builds the case for ongoing RD&D across entire CCUS supply chain
- Economic benefits assessment (e.g., jobs, GDP)

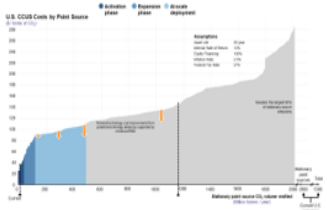
U.S. CCUS cost curve



Differential feature – phases of implementation

Study lays out a three phases – Activation, Expansion and At-Scale:

- Prioritized based on economics and ease of implementation
- Specific recommendations
- Economic benefits – GDP and jobs



Categories of recommendations

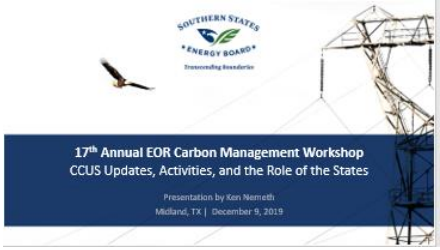
Across the thee phases of implementation, the roadmap to at-scale deployment details recommendations in four key areas:

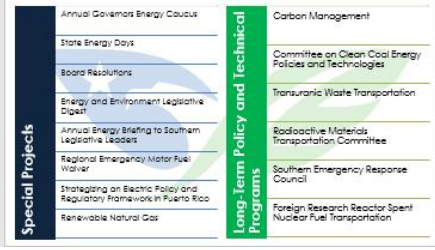
- Financial incentives
- Supportive legal and regulatory frameworks
- Technology and capability
- Stakeholder engagement

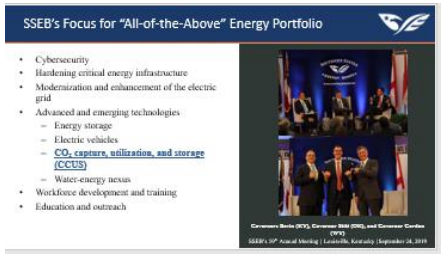
Study timing

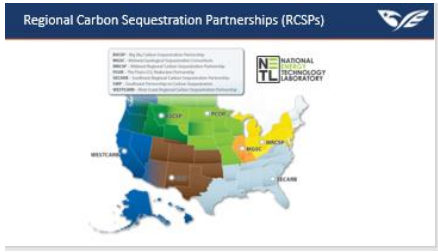
- Approval by NPC membership, presentation to Secretary of Energy, and public release scheduled for December 12
- December 12 meeting of the NPC and report presentation will be webcast via NPC website: www.npc.org
- Public release of NPC approved report will also be available for viewing and download via NPC website.

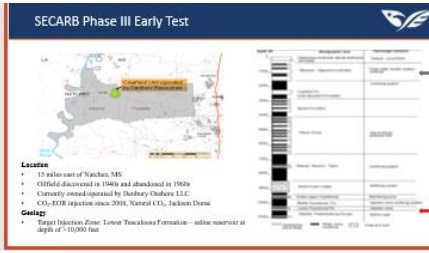
Ken Nemeth Executive Director SSEB

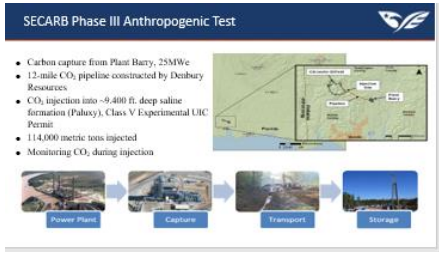


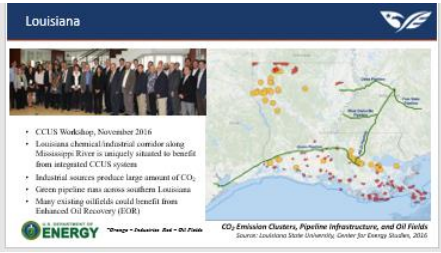


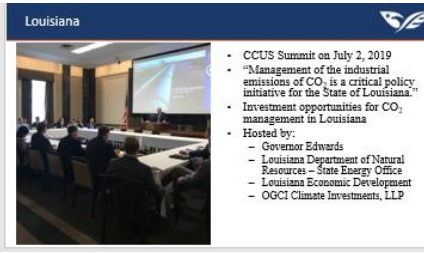


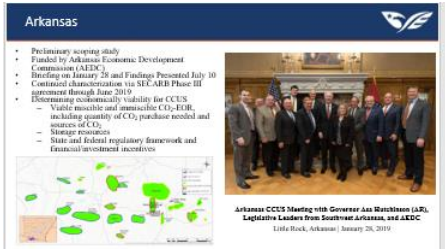


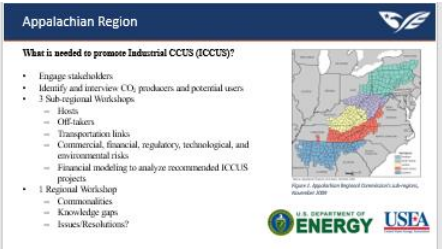


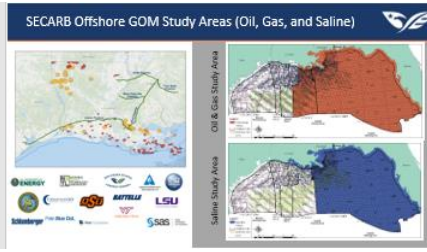












Regional Initiative to Accelerate CCUS Deployment

SECARB-USA Region
Alabama
Arkansas
Florida
Georgia
Louisiana
Mississippi
North Carolina
South Carolina
Tennessee
Virginia

and portions of:
Kentucky
Missouri
Oklahoma
Texas
West Virginia

Acceleration
- 5 years (2019-2024)
- 4 Partnerships
- $20M DOE and cost share

SECARB-USA Primary Research Areas

- address key technical challenges;
- facilitate data collection, sharing and analysis;
- assess transportation and distribution infrastructure; and
- promote regional technology transfer and dissemination of knowledge.

CCUS: The Role of States

- Reduce uncertainty to encourage investment
  - Education
  - Policy
  - Regulatory
  - Primacy over Underground Injection Control well classes
- Education and outreach to industry regarding state and federal incentives
  - Federal: U.S. Internal Revenue Code Title 26, Sections 45Q and 48A (technical modifications for retrofits)
  - 45Q U.S. Treasury guidance (SSEB Resolution 7.2019)
- Workforce development

2019 Adopted Resolutions

7.2019 - Accelerating Commercial Investments in Carbon Dioxide (CO_2) Capture, Utilization, and Storage at Conventional Power Plants

Sen. Yager (TN), Rep. Sandifer (SC), Sen. Stubblefield (AR)

"…urges Treasury to use all necessary resources available to finalize its review of comments received from Notice 2019-32 and issue final regulations associated with carbon capture, storage and utilization under 45Q."

"…requests that Congress consider amending and extending, for a minimum of two years, the construction commence date of January 1, 2024, in Section 45Q of the Internal Revenue Code regulations as amended by The Bipartisan."

"…encourages Congress to support deployment of conventional generating technology to maintain fuel diversity and ensure energy security by enacting technical modifications to Section 48A of the Internal Revenue Code that are needed to incentivize investment of CO_2 capture on new and existing conventional power generating units. Budget Act of 2018 to account for the delay in Final Regulations being issued by Treasury."

Visit https://www.sseb.org/publications/resolutions/ to download recently adopted resolutions.

2019 State CCUS Legislative Action

- **Indiana (SB 442) – Rules Regarding CO_2 Storage Underground**
  - Declares the underground storage of carbon dioxide to be a public use and service, in the public interest, and a benefit to the welfare and people of Indiana
  - Authorizes the West Terre Haute (ammonia production facility) pilot project and the power of eminent domain for subsurface ownership
  - Provides state ownership of CO_2 after 12 years
  - Urges the legislative council to assign an interim study committee for studying the geologic storage of CO_2
- **Louisiana (HB 163) – Responsible Persons for Actions Related to CO_2 Sequestration**
  - Provides that the responsibility of performing requirements of the Louisiana Geologic Sequestration of Carbon Dioxide Act falls only on storage operators

2019 State CCUS Legislative Action

- **New York (SB 6599) – Establishing the New York Climate Leadership and Community Protection Act**
  - Establishes the New York state climate action council to initiate advisory panels on transportation, energy intensive and trade-exposed industries, land-use and local government, energy efficiency and housing, power generation, and agriculture and forestry
  - Calls for a final scoping plan to be delivered within 3 years that identifies and makes recommendations on regulatory measures and other state actions that will ensure the attainment of the statewide greenhouse gas emissions limits established by this article.
    - Performance-based standards for sources of greenhouse gas emissions, including but not limited to sources in the transportation, building, industrial, commercial, and agricultural sectors
    - Measures to reduce emissions from the electricity sector by displacing fossil-fuel fired electricity with renewable electricity or energy efficiency
    - Measures to achieve long-term carbon sequestration and/or promote best management practices in land use, agriculture and forestry

2019 State CCUS Legislative Action

- **North Dakota (HB 1439) – Tax Exemptions for Projects Using CO_2 from Coal or Oil Extraction**
  - Expands the oil extraction tax exemption for incremental production from certain tertiary recovery projects using carbon dioxide from coal; and creates a property tax exemption for qualifying pipelines and a sales tax exemption for materials used in secure geologic storage.
- **Texas (HB 3838) – Offers Disclosure for Mineral or Royalty Interest**
  - Requires a mineral or royalty interest conveyance instrument specified by the bill to include a conspicuous statement printed at the top of each page in a type size of at least 14 points
  - The statement is required to provide that the offer was not a lease and that the owner would be selling all or a portion of the owner's mineral or royalty interests. Conveyance instruments without such information would be void.
- **Virginia (HB 2845) – Industrial Development Authority Support for Landowner Access to Carbon Markets**
  - Authorizes an industrial development authority to facilitate and support landowner access to carbon markets through aggregation of landowners to reach a size that attracts the investment of private capital.

Upcoming Events

December 11-12, 2019	Joint Meeting of SSEB's Radioactive Materials Transportation Committee and Transuranic Waste Transportation Working Group	Miami, Florida
February 7-10, 2020	National Governors Association Winter Meeting	Washington, DC
February 2020	SSEB Associate Members Winter Meeting (held in conjunction with the National Governor's Association Winter Meeting)	Washington, DC
March 2020	Southeast Regional Carbon Storage Partnership: Offshore Gulf of Mexico, Stakeholders Briefing	New Orleans, Louisiana
March 2020	Southeast Regional Carbon Storage Partnership: Offshore Gulf of Mexico, Joint Meeting with GoMCarb	New Orleans, Louisiana
May 2020	SSEB Committee on Clean Coal Energy Policies and Technologies (held in conjunction with the Virginia Coal and Energy Alliance's Annual Meeting)	Kingsport, Tennessee
August 1, 2020	SSEB Annual Energy Briefing to Southern Legislative Leaders	Winston-Salem, North Carolina
Fall 2020	SSEB 68th Annual Meeting, Hosted by Oklahoma Governor J. Kevin Stitt	Oklahoma

https://www.sseb.org/news-and-events/

Tiffany Wu Business Development
Mitsubishi Heavy Industries Group

KM CDR Process™
Post-combustion CO_2 Capture Technology

2019 CO2 & ROZ Conference
Carbon Management Workshop
Midland, Texas

December 9, 2019

Agenda

1. Introduction to MHI
2. MHI's KM CDR Process™ overview and experience
3. Advanced KM CDR Process™
4. What's next?

Introduction to MHI

Mitsubishi Heavy Industries Group Domains and Products

MHI GROUP DOMAINS

COMPANY HIGHLIGHTS

$36.7BN Annual revenue	More than 25,600 Patents	54% Sales outside Japan
$1.7BN Operating income	80,744 Employees worldwide	235 Domestic & overseas companies

MHI IN NORTH AMERICA

- 9,300+ EMPLOYEES
- 100+ OFFICE & FACTORIES
- 3,927 PATENTS
- $6.0BN IN REVENUE
- Relationships with around 200 SUPPLIERS

MHIA Engineered Systems Division

MHI America, Inc.'s Engineered Systems Division, based in Houston, provides sales, administration, engineering, and project management support for MHI Engineering, Ltd.'s business in the US.

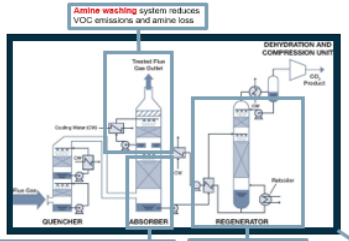
ENGINEERING A RELIABLE FUTURE

Mitsubishi Heavy Industries Engineering offers reliable technologies gained from engineering synergies realized within the Mitsubishi Heavy Industries (MHI) Group.

We contribute to the development of society by supplying numerous EPC (Engineering, Procurement, Construction) projects covering large-scale infrastructure, such as chemical plants, environmental plants, and transportation systems, in many countries and regions around the world.

MHI's KM CDR Process™ overview and experience

KM CDR Process™ Overview and Features



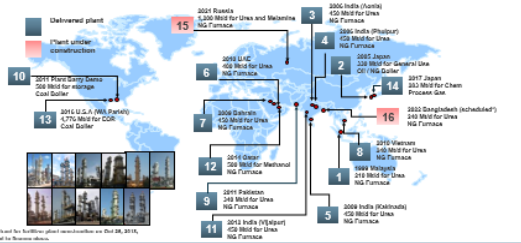
- KM CDR Process™ = *Kansai Mitsubishi Carbon Dioxide Recovery Process*
- Capable of capturing ~90+% CO_2 from combustion gas sources
- CO_2 purity >99.9% (dry basis)
- Amine-based technology
- Proprietary features developed over 29 years of experience
  - Automatic load adjustment control
  - Amine filtration and purification systems
  - Proven tower design for even gas/liquid distribution

KM CDR Process™ Technology Development Timeline

- Began R&D with Kansai Electric Power Co. - 1990
- 2 tpd pilot plant at KEPCO's Nanko Power Station - 1991
- Developed KS-1™ and KM CDR Process™ - 1994
- 1999 - 200 tpd plant in Malaysia
- 1st commercial deployment on NG
- Evaluated coal flue gas effect
- 1 tpd coal pilot test at Hiroshima R&D Center - 2002
- Developed proprietary energy efficient process - 2003
- Made technology more efficient
- 2006 - 330 tpd plant in Japan
- 10 tpd coal pilot test at Matsushima - 2009
- 2008 - two 450 tpd plants in India
- Long-term performance on coal
- Large absorber flow test at Mihara works - 2008
- Key test for scale-up
- 2009 - 450 tpd plant in India; 450 tpd plant in Bahrain
- 2010 - 400 tpd plant in UAE; 240 tpd plant in Vietnam
- 2011 - 340 tpd plant in Pakistan
- 2012 - 450 tpd plant in India
- Plant Barry 500 tpd demonstration project – 2011-2014
- Large-scale demonstration on coal
- 2014 - 500 tpd plant in Qatar
- 1st commercial deployment on coal
- 2016 - Petra Nova Project – 4,776 tpd plant in Texas

KM CDR Process™ Commercial Experience

MHI is the world leader in large scale CO_2 capture plant deployments.



Petra Nova CO_2 Capture Plant for CO_2 EOR

Power Magazine "Plant of the Year" August 2017

Petra Nova Project "On-Budget and On-Schedule"

MHI delivered the world's largest post-combustion CO_2 capture plant

Fall 2016 View of the Site

The Petra Nova Project is MHI's first commercial power project. Performance test was completed in December 2016.

- Plant is owned by NRG and JX Oil & Gas.
- Located at NRG's WA Parish Plant Unit 8 near Houston, TX.
- Captures 4,776 metric tons/day (240 MWeq, 90% capture) from a ~37% flue gas slip stream (1.4 million metric tons/year).
- MHI and TIC consortium provided full turnkey EPC delivery of the CO_2 capture plant.

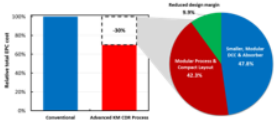
Advanced KM CDR Process™

Recent learnings to be applied

Operating CO_2 capture plants on coal fired flue gas has provided valuable insights that can be implemented into the next projects.

- *Re-evaluate equipment and tower design based on actual performance.*
- *Modularize, and optimize plot plan.*
- *Develop realistic gas impurity assumptions during design.*
  - Impurity concentrations greatly affect the design of mitigation processes.
- *Increase design capture rate from 90% to 95% at same $/ton cost basis.*

Advanced KM CDR Process™ – Capital cost optimization



Cost Relative to conventional	Conventional	Advanced KM CDR Process
Pumps	100	49
Heat exchangers	100	80
Tower internals	100	74
Filtration system	100	43
Tanks	100	74

Spec Relative to conventional	Conventional	Advanced KM CDR Process
Footprint [% in m^2]	100	75
Structural steel [% in tonnes]	100	70
Piping [% in tonnes]	100	79

- ✓ **Technology risks are significantly reduced after large-scale unit experience**
- ✓ **Improvement from new technology & lessons learned**
  - Reduce height of DCC and Absorber which are the major cost centers (>30% of CAPEX)
  - Reduce Regenerator diameter by 10% by selecting new packing
  - Optimize equipment design
- ✓ **Optimized & minimized layout and modular design**
  - Fabricated in shop as skids to reduce on-site fabrication, reducing construction labor hours by 60% and improving productivity, schedule & budget control
  - Minimized footprint reduces material quantities resulting lower construction cost

Advanced KM CDR Process™ – New Solvent

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

- ✓ **Thermal stability**
  - Reduce thermal degradation and allow higher stripping T and P, reducing compression work
- ✓ **Oxidative stability**
  - Potentially more tolerant to impurities
  - Reduce amine oxidation and HSS formation rate
- ✓ **Volatility**
  - Reduce amine loss from emission and cost of water wash system
  - Steam consumption savings outweigh cost increases due to higher solvent circulation

FEED studies initiated in 2019 using the Advanced KM CDR Process™ and KS-21™ solvent.

MOVE THE WORLD FORWARD · MITSUBISHI HEAVY INDUSTRIES GROUP

What's next?

Department of Energy FOA 2058 FEED Support

FOA 2058: Front-End Engineering Design (FEED) Studies for Carbon Capture Systems on Coal and Natural Gas Power Plants

Full-Scale FEED Study for Retrofitting the Prairie State Generating Station with an 816 MWe Capture Plant Using Mitsubishi Heavy Industries of America Post-Combustion CO_2 Capture Technology – **The Board of Trustees of the University of Illinois** (Champaign, IL) will complete a FEED study for the installation of a carbon capture system at the Prairie State Generating Company's (PSGC) Energy Campus in Marissa, Illinois. The project will be based upon the Advanced KM CDR Process™ carbon dioxide (CO_2) capture technology from Mitsubishi Heavy Industries. The project team that successfully completed the Petra Nova capture plant in Thompsons, Texas has been reassembled to benefit from lessons learned. The Advanced KM CDR Process is an amine-based capture system that uses the KS-21 solvent. If successful, the project would provide valuable insight into lowering the cost of carbon capture systems.

Prairie State Energy Campus Project

Host site:	Prairie State Energy Campus
Owner:	Prairie State Generating Company
Location:	Marissa, Illinois
Load:	816 MWe
Technology:	Advanced KM CDR Process™ with KS-21™
Team:	- University of Illinois - Mitsubishi Heavy Industries - Kiewit - Sargent & Lundy

MHI's KM CDR Process™ can be used on a variety of flue gases

The KM CDR Process™ has been applied to a variety of gases, and the effects of various impurities on the amine and the system have been tested.

Tested gases include:
- Natural gas-fired boiler exhaust
- Oil-fired boiler exhaust
- Coal-fired boiler exhaust
- Gas turbine exhaust (simulated)

Industrial applications:
- Power plants (NGCC, coal-fired, or biomass)
- Steam methane reformer furnace exhaust
- Cement plants
- Steel plants
- Catalytic crackers
- Natural gas processing

Typical Flue Gas Conditions

	Unit	Coal fired Boiler	NG fired GT	NG fired Boiler
CO_2	Vol.%	10 - 14	3 - 4	8 - 9
O_2	Vol.%	4 - 6	10 - 15	1 - 2
SOx	ppm(dry)	1 - 50	<0.3	<1
PM (Dust)	mg/Nm³	3 - 10	NA	NA

Possible constituents in the flue gas depending on the industrial application:
- NOx
- CO
- H_2S
- Hydrocarbons
- Heavy metals
- Halides (HCl, HBr, HF)

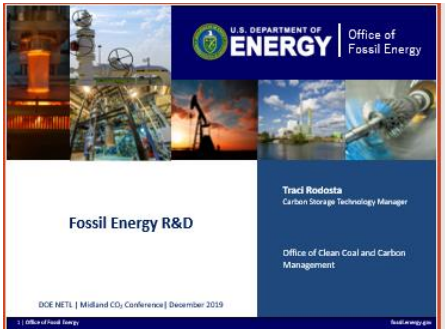
Thank you!

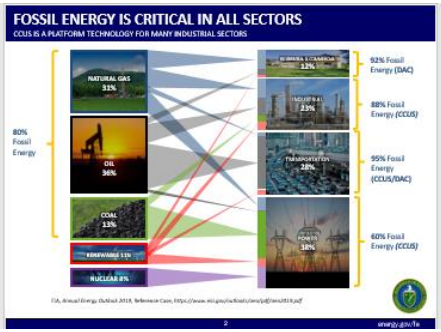
Come visit our booth!

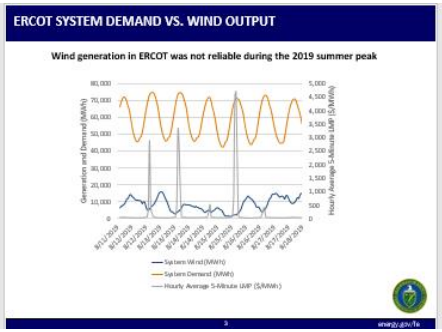
MOVE THE WORLD FORWARD

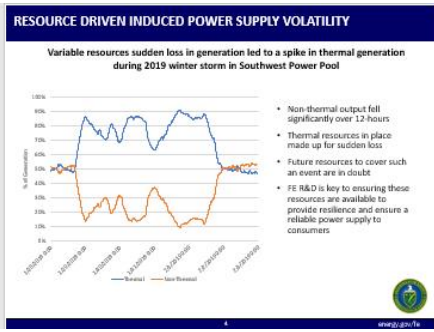
MITSUBISHI HEAVY INDUSTRIES GROUP

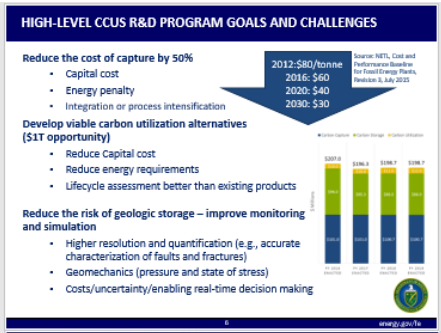
Traci Rodesta Carbon Storage Manager DOE/NETL

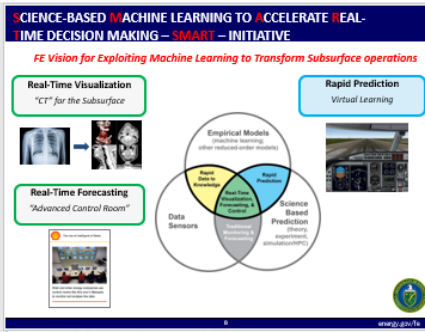


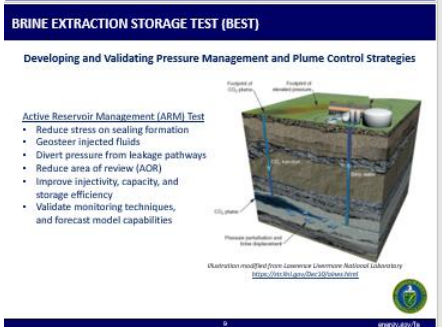


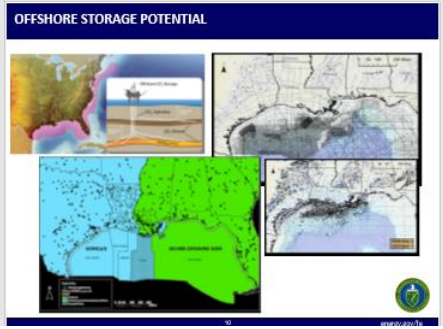


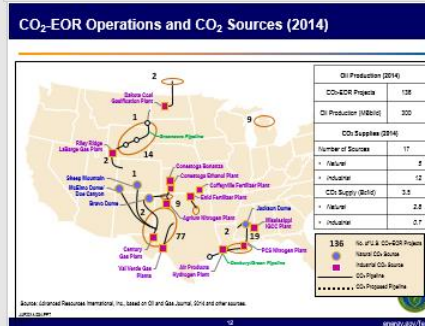


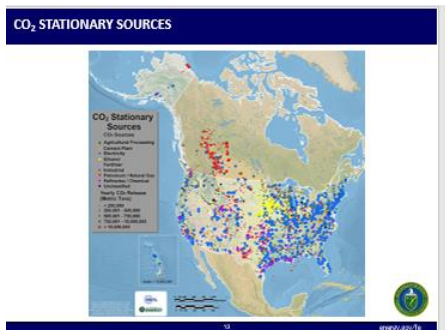


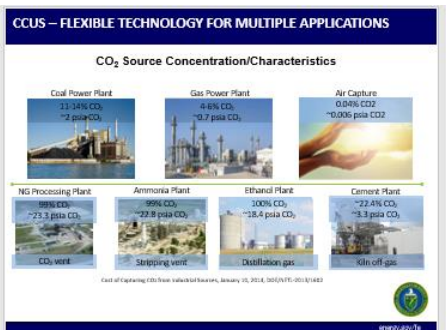


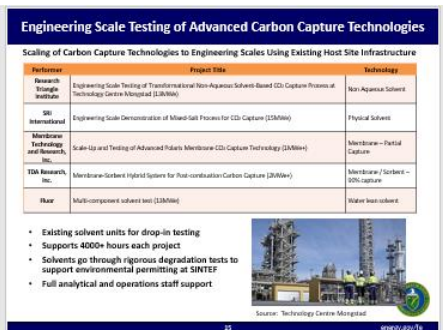


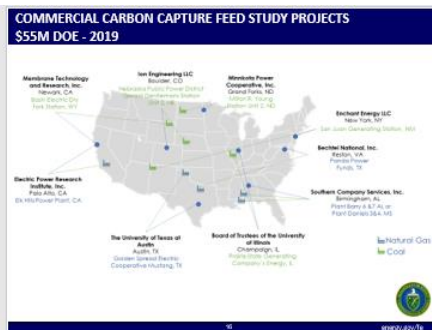




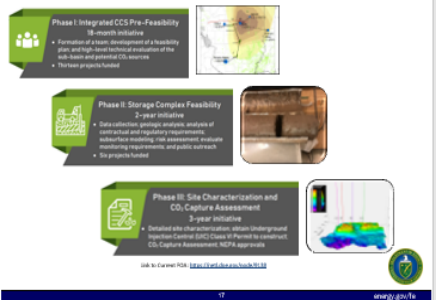






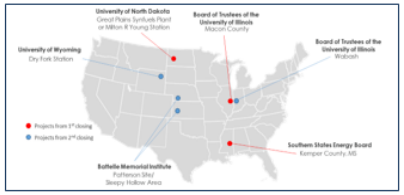


CARBON STORAGE ASSURANCE FACILITY ENTERPRISE –CARBONSAFE

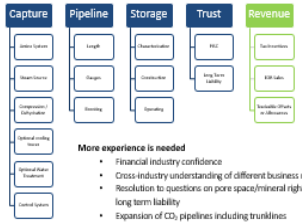


CARBON STORAGE ASSURANCE FACILITY ENTERPRISE –CARBONSAFE

Reducing Risk—Increasing Certainty—Decreasing Costs



BUSINESS CASE DEVELOPMENT



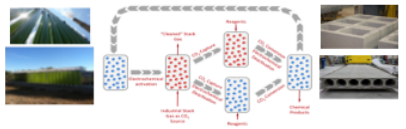
More experience is needed

- Financial industry confidence
- Cross-industry understanding of different business models
- Resolution to questions on pore space/mineral rights and long term liability
- Expansion of CO_2 pipelines including trunklines
- Additional tools to help complete the CCUS toolbox
- Enabling operators to meet regulatory requirements

CARBON UTILIZATION

OFFSET CO_2 CAPTURE COSTS + FIX CO_2 IN STABLE PRODUCTS

Biological Capture & Conversion | Fuels & Chemicals | Mineralization & Cements



24 Active Projects – Recently selected 11 lab and 4 field-scale projects

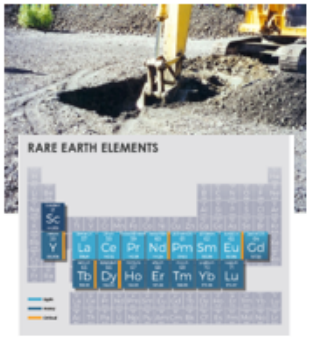
Catalysis and Biological Pathways - Fuels and Chemicals

- Projects creating CO or direct to fuels using low-carbon energy and/or hydrogen

Concrete: Solidia Technologies - Utilizes CO_2 to make cement and concrete

- Reduce carbon footprint up to 70%
- $1.9M DOE investment leveraged by industry
- Oil and Gas Climate Initiative's Climate Investment Funded and other parties

COAL UTILIZATION – ADVANCED MATERIALS



Critical Minerals

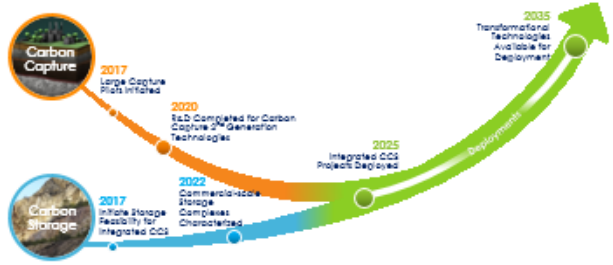
- Cobalt: 1,000+ PPM
- Nickel: 900+ PPM
- Manganese: 1.5+ wt%
- Rare Earths: 800+ PPM
- Zirconium: 2+ wt%
- Hafnium: 500+ ppm
- Yttrium: 1,000+ PPM
- Alumina: 30+ wt%)

Advanced Materials

- Graphite
- Graphene
- Carbon fiber
- Coal pitch
- Needle coke

FUTURE COMMERCIAL-SCALE DEPLOYMENT

Integrated R&D Approach



Keith Tracy - David Lowman - Tracy Evans

45Q Implementation
December 2019 Update

CornerPost — Keith Tracy
HUNTON ANDREWS KURTH — David Lowman
Perdure Petroleum — Tracy Evans

Background

- 26 U.S.C. §45Q was enacted Oct 3, 2008
  - IRS issued Guidance in 2009 (Notice 2009-83)
  - No regulations were ever proposed or adopted
- Section 45Q was amended effective Feb 9, 2018
- 45Q was the 2018 CO2 Conference "Seminar" topic
  - "45Q and CO2 EOR's Vital Role in Carbon Management, and ROZ CO2 EOR"
  - Download full-day of slides for $50 at https://www.co2conference.net/product/2018-co2-and-ccs-seminar/

2019 Activity

- IRS issued Notice 2019-32 on May 20, 2019, requesting comments
  - IRS identified 10 specific questions to be answered
  - IRS Solicited comments on all issues related to 45Q amendments
  - IRS mentioned that permanent rules or other sub-regulatory guidance would be developed
  - IRS had earlier predicted the Notice was to be issued in Feb/Mar 2019, but Notice wasn't issued until May 2019
- 105 comments were submitted by the public

Update: Anticipated IRS Actions

Most recent update from IRS was Nov 26, 2019

We are hearing that IRS currently intends to issue 3 different documents to provide interpretation/application of §45Q

1. Revenue Procedure: addressing structuring and partnership-related issues
2. IRS Notice: providing guidance on beginning of construction requirements
3. Notice of Proposed Rule Making (NPRM): regulations addressing all other matters

1. Revenue Procedure

- IRS may issue a "Revenue Procedure" to address structuring and partnership-related issues for §45Q
  - "Revenue Procedure" type of guidance was used by IRS on partnership issues on other tax credits (i.e. wind PTC; historic rehabilitation ITC)
- Timing
  - Initially was projected to be issued end of Nov 2019
  - Now projected to be issued end of Dec 2019 at the earliest

2. Guidance/Notice

- IRS may issue a Notice providing guidance addressing beginning of construction related issues for §45Q
  - IRS Notices were issued by IRS on beginning of construction requirements on other tax credits (i.e. wind/solar)
- Timing
  - Initially was projected to be issued end of Nov 2019
  - Now projected to be issued end of Dec 2019

3. Notice of Proposed Rule Making (NPRM)

- IRS may issue a "Notice of Proposed Rule Making" to adopt regulations for all other §45Q issues
- Timing
  - Initially was projected to be issued end of Dec 2019
  - Now projected to be issued in 1st quarter 2020
- Anticipated impact:
  - The notice would contain proposed regulations, and an opportunity for written comment (typically 60-90 days) followed by a public hearing
  - The proposed regulations would be temporary regulations that can be immediately relied upon until final regulations are issued
- Possibility of IRS Guidance prior to NPRM

Beginning of Construction – Expected Guidance

- Construction must begin before January 1, 2024
- Two alternative ways to show beginning of construction "BOC":
  - Physical work of a significant nature has begun
  - 5% Safe Harbor
- Physical work test:
  - Physical work of a significant nature is a facts and circumstances test
  - Focuses on the nature of the work performed, not the amount or cost
- On-site and off-site work:
  - Any physical work on-site on the qualified facility
  - Physical work off-site for property included in the qualified facility
- Work done by the taxpayer and its contractors under a binding written contract
- Physical work must be "continuous" after BOC

Beginning of Construction – Expected Guidance

- The 5% Safe Harbor: Construction of a facility will be considered as having begun, if:
  - a taxpayer incurs five percent or more of the total cost of the project before January 1, 2024, and
  - thereafter, the taxpayer makes continuous efforts to advance towards completion of the facility
- "Continuous" Program of Construction or Physical Work
  - Generally determined on a facts and circumstances basis-however:
  - IRS has provided a "Continuity Safe Harbor" to wind and solar of 4 calendar years from the year in which construction starts
    - CCUS participants have asked for 6 years

Partnership Structure – Expected Rev Proc

IRS provided safe harbor guidance in Rev Proc 2007-65 to taxpayers on how to structure wind transactions using the partnership-flip structure. The IRS is expected to issue a similar Rev Proc for 45Q. Expected issues to be addressed:

- Definition of Investor and satisfaction of economic substance doctrine
- Minimum partnership interest. Investor may take up to 99% of tax items, but not less than 5%
- Minimum unconditional upfront investment of at least 20%
- Contingent consideration. CCUS industry has asked for 50% contingent
- Restrictions on sponsor purchase options
- Restrictions on Sale Rights. CCUS industry participants have asked for approval of a "put right"
- Guarantees. No party may guarantee the tax credit to the investor. CCUS industry participants have asked that guarantees of level of CO2 production, environmental issues, and recapture risk, among others, be treated as permissible guarantees

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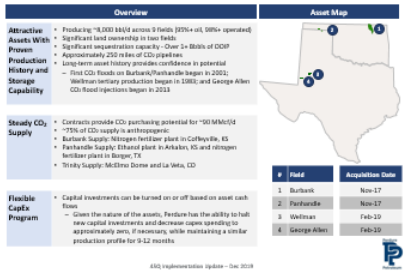
Perdure Petroleum – Executive Summary



EOR Operator Perspective

- Fielding numerous calls from potential CO_2 providers
  - We have two projects internally, one which we are preparing for 45Q implementation and the other is less certain
- Potential Issues
  - Review of final regulations
  - Given our LLC structure, 45Q credits pass through to our equity investors
    - LLC maintains the cost of MRV, long term liability and compliance
    - Tax Equity partnership
      - Allocation of MRV, long term liability and compliance costs
      - Liability of failure to achieve minimum threshold
  - Many CO_2 Purchase contracts signed before 2018 allocated the 45Q credits inconsistent with the revised 45Q law/regulations
    - Contracts may need to be re-negotiated to align with updated regulations
    - Most have no monetary penalty in the event the CO_2 source fails to deliver
  - Minimum volume threshold concerns might require changes to EOR Operator's development plan(s)
    - EOR Field downtime
    - CO_2 Source downtime

Patricia Loria Global CCS Institute

GLOBAL STATUS OF CCS: THE NEXT WAVE IS COMING

25th Annual CO2 Conference

PATRICIA LORIA
Senior Client Engagement Lead
December 9, 2019

GLOBAL CCS INSTITUTE

THE GLOBAL CCS INSTITUTE

International think tank

Backed by governments, businesses and NGOs

Mission: To accelerate deployment of CCS

62 MEMBERS

7 locations

Advocacy, Intelligence, Connections

LARGE SCALE CCS FACILITIES

Recent developments

	Operating	In construction	In development
April 2019	18	5	20
	+1	-1	+8
Current	19	4	28

Facilities added

- ARK ENERGY CCS PHASE 2
- EI PASO BAY PROJECT
- HUSKY ENERGY
- OXY AND WHITE ENERGY ETHANOL
- PROJECT TUNDRA
- SKY POINT
- CARBONSAFE II | MOB
- OXY AND CARBON ENGINEERING D.A.C.
- SITRA/TYRO BIO CONTRACT
- FCCSB

NEXT WAVE OF CCS: HUBS & CLUSTERS

- Multiple industrial point sources of CO2 connected to a CO2 transport and storage network.
- Access to large geological storage resources with the capacity to store CO2 from industrial sources for decades.
- Economies of scale deliver lower unit-costs for CO2 storage.
- Synergies between multiple CO2 sources and the storage operator reduce cross chain risks and support commercial viability.

PROJECTS – NORTH AMERICA

Established Projects

Project Tundra - North Dakota, USA
- Minnkota Power Cooperative and BNI Energy are collaborating with state resources on carbon capture at the Milton R. Young coal power plant.
- Over 3Mtpa to be stored geologically or via EOR.
- The project is in advanced development stage and will utilize Fluor's Econamine FG Plus technology.
- Received support from DOE via CarbonSAFE storage feasibility study and early design research support.
- Recently granted additional DOE funding for FEED study.
- Could be in operation by 2025.

Lake Charles Methanol – Louisiana, USA
- Project in Lake Charles will capture and store over 4Mtpa.
- Benefiting from $2billion DOE loan guarantee, 45Q, and Louisiana regulatory support.
- Fluor EPC contract signed in March 2016; working with Morgan Stanley to finalize investors with projected 2024 completion.

OXY and White Energy Ethanol – Texas, USA
- Project would use 300,000tpa CO_2 from each of White Energy's Hereford and Plainview plants for EOR in the Permian.
- Could be operational as early as 2021.
- Would benefit from 45Q and California's LCFS incentives.

WHITE ENERGY

PROJECTS – NORTH AMERICA

Wabash Valley Fertilizer plant – Indiana, USA
- Repurposed Wabash Integrated Gasification Combined Cycle plant for ammonia production in Terre Haute, Indiana.
- Will store 1.5 - 1.75Mtpa in Illinois Basin.
- First hub and cluster model in US with co-benefits on storage side from ADM project.
- Could be operational in 2021.
- Funded in part by CICC/ Climate Investments and received DOE funding for its pre-feasibility study.
- Project will benefit from Indiana state government legislative support and 45Q.

California Research Corporation – California, USA
- Planned CCS facility capable of capturing 1.4Mtpa CO_2 from the 550 MW Elk Hills Power Plant located in the Elk Hills oil field and fired using natural gas produced by the field.
- The captured CO_2 would be used for enhanced oil recovery in the Elk Hills oil field.
- This project would benefit from both 45Q and California LCFS.
- Electric Power Research Institute received DOE funding to conduct FEED study using Fluor technology.

Oxy and Carbon Engineering – TBC Permian, USA
- Oxy announced plans with Carbon Engineering to put a Direct Air Capture facility near an oil field in the Permian.
- The captured CO_2 would be used for EOR.
- Estimated that the plant will capture between 0.5 and 0.9Mtpa.
- This project would take advantage of 45Q and the California LCFS.

PROJECTS – NORTH AMERICA

Early Development

Pacific Ethanol - Illinois, USA
- Aim to sequester CO_2 from facilities located in Pekin, IL.
- Will benefit from work done at ADM and project with Wabash Valley, partnering with the Illinois State Geological Survey.

Delta California Carbon Capture Program - California, USA
- Project is envisioned to be a regional network of carbon sequestration hubs to serve industrial customers in California.
- The initial goal to store 1Mtpa in deep saline aquifers or depleted oil and gas formations.

Elysian - Texas, USA
- Aim to execute 10 projects at 1,000,000 tons per year before the expiration of 45Q legislation.
- Target sites in Texas have already been identified with a focus on natural gas fired power plants.

Velocys – Natchez, Mississippi
- Oxy signed an agreement to capture and store the CO2 from their Bayou Fuels biomass-to-fuels project in Natchez, Mississippi. It is presumed that the CO2 will be used for EOR.

Additional projects supported through latest round of DOE funding:

Basin Electric's Dry Fork Station – Gillette, Wyoming, USA
- Funding for commercial-scale FEED.
- Using MTR's Membrane CO_2 Capture Process.

San Juan Generating Station - Waterflow, New Mexico, USA
- DOE funding for FEED study to determine the technical and economic feasibility.

Prairie State Generating Station- Marissa, Illinois, USA
- US DOE funded $15 million for a FEED study for the installation of capture system at the Prairie State Generating Company's Energy Campus using Advanced KM CDR Process KS-21 solvent.

PROJECTS – ASIA PACIFIC

Operation/Construction

Chevron Gorgon- Western Australia
- In August Chevron announced safe startup and operation of Gorgon CO_2 injection facilities.
- When fully operational, this will be the largest geological storage facility in the world with capture capacity of 3.4 - 4Mtpa.
- Chevron has blamed technical issues for the 2 year delay citing excess water entering the pipeline and injection well, which increases the risk of corrosion.

Osaki CoolGen - Hiroshima, Japan
- A166MW oxygen blown Integrated Coal Gasification Combined Cycle (IGCC) demonstration plant.
- First phase of the project, construction and demonstration of IGCC completed 2018.
- CO_2 capture plant is currently being commissioned and is expected to commence operation in December.
- Plant uses a physical adsorbent (Selexol Max) and will capture up to 400t CO_2 per day.
- The next stage is the installation of two 600kW Solid Oxide Fuel Cells to produce additional electricity from hydrogen produced by the gasifier.

PROJECTS – ASIA PACIFIC

Established Projects

CarbonNet Project - Victoria, Australia
- CarbonNet will drill an appraisal well between early-November and December to verify suitability of the Pelican site in the Bass Strait.
- During drilling, the Noble Tom Prosser rig will be approximately 8km offshore and may be observed from the shoreline.
- Environment plan for the offshore appraisal well was approved by the National Offshore Petroleum Safety and Environmental Management Authority in April 2019.
- Call for submission regarding business model/financing expected.

Sinopec, Shengli Oil Field - Shandong province, China
- The project captures CO_2 from fertilizer production for CO_2-EOR.
- The project had difficulties in contracting with the fertilizer producer (pricing of CO_2).
- FEED has been completed and pilot injection started.
- Supercritical CO_2 transportation by pipeline had public opposition so trucks are currently being used for transport.

Xinjiang Dunhua Oil – Xinjiang, China
- CO_2 from PetroChina methanol plant captured using amines.
- The project has been operational since November 2015.
- The company has management contract with PetroChina for CO_2-EOR operation (whole-chain).
- The plant has a capacity of 100,000tpa.

PROJECTS – ASIA PACIFIC

Early Development

Santos CO_2-EOR – Cooper basin, Australia
- CO_2-EOR project in central Australia.
- Project is currently at pre-FEED stage.
- CO_2 from natural gas processing.

Bridgeport Energy CO_2-EOR - Queensland, Australia
- CO_2-EOR project in southern Queensland.
- Currently identifying economical CO_2 sources.

ENI, Australia – Offshore, Northern Australia
- Offshore high CO_2 gas field.
- Growing regional interest in CCS to address increased CO_2 emissions from LNG plants.
- Export will be via Darwin LNG plant.
- Early storage potential appraisal completed.

CNPC Chengqing Oilfield – Inner Mongolia, China
- CO_2 from natural gas processing.
- CO_2 EOR storing 100,000tpa.

China Energy Corporation –China
- CO_2 captured from Coal-fired power station.
- Capturing 120,000tpa.
- Currently at FEED stage.

CNPC CEEC 中国能建

PROJECTS – ASIA PACIFIC

Gundih CO2 Project - Central Java, Indonesia
- Captures CO_2 from a natural gas processing plant in Gundih, Central Java, Indonesia.
- Oil/gas field is owned by Pertamina and contains circa 20% CO_2.
- Technical Assistance project funded by Asian Development Bank.
- Japan International Cooperate Agency also provided support.
- Includes capturing and preparing CO_2; transporting and injecting CO_2; monitoring.
- The project includes study of CCS regulation in Indonesia.

Petronas K6 - Offshore Sarawak, Malaysia
- High CO_2 gas field(70% CO_2)
- Pilot injection planned 2022.
- CO_2 storage assessment stage.

ERG – North East, Kazakhstan
- CO_2 captured from power stations.
- Early concept stage.

KEPCO Boryeong Power Station - Korea
- CO_2 from a coal-fired power station.
- Storage unclear.

Dalmia Cement – Tamil Nadu, India
- Dalmia is the first cement company to commit to being 'Carbon Negative' aiming to do so by 2040.
- Dalmia Cement and Carbon Clean Solutions have teamed up to develop a 500,000tpa CCU plant at one of Dalmia's facilities in Tamil Nadu, India.
- The partnership will explore how CO_2 can be used, including direct sales to other industries and using the CO_2 as a precursor in manufacturing chemicals.

PROJECTS – EUROPE

Established Projects

Acorn - St Fergus, Scotland
- Shell is working on technical studies for the Acorn project.
- E&P firm Chrysaor has also become a partner in Acorn.
- Pale Blue Dot were awarded £453,706 by the UK Government for Feasibility work as part of Hydrogen supply programme during August.

Porthos - Rotterdam, Netherlands
- Early 2019 several companies signed a non-binding EOI for storage. Companies who sign agreements by October 1st will get preferential right to capacity. Porthos aims to finalise T&S contracts summer 2020.
- A second phase is proposed to increase offshore network capacity. Emitters in NL and imports from Germany are likely CO_2 sources.
- Wim Lieshout appointed as Project Director succeeding Tim Bertels.
- FID currently expected early 2021.

Norwegian Full Chain - Various, Norway
- Partners to undertake investment decision late 2019/early 2020.
- Project will be subject to parliamentary approval 2020/2021.
- Characterisation drilling is expected to begin mid-October and last 79 days. The North Atlantic-owned rig, West Hercules will be used.
- On September 5th Equinor announced the signing of agreements to develop CCS value chains with Air Liquide, Arcelor Mittal, Engie, Fortum Oyj, Heidelberg Cement AG, Preem, and Stockholm Exergi.

PROJECTS – EUROPE

Early Development

3D project ArcelorMittal - Dunkirk, France
- The "3D" project (DMX Demonstration in Dunkirk) is part of the Horizon 2020 research and innovation program.
- Coordinated by IFPEN, the project brings together 10 partners from research and industry: ArcelorMittal, Axens, Total, ACP, Brevik Engineering, CMI, DTU, Gassco, RWTH and Uetikon.
- The project objective is threefold:
  - Demonstrate the DMX process at industrial scale.
  - Prepare the implementation of a first industrial unit at the ArcelorMittal steel production site in Dunkirk, which could be operational in 2025.
  - Design the future European Dunkirk North Sea cluster, which should be able to capture, transport and store 10Mtpa.

stockholm exergi

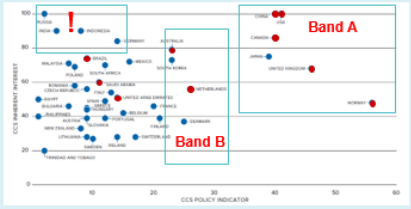
Värtan CHP plant – Stockholm, Sweden
- Stockholm Exergi AB will install a carbon capture test facility at its biomass-fired KVV8 unit at the Värtan CHP plant in Stockholm.
- An eight-month test programme will start during autumn 2019
- In January 2019, Hot Potassium Carbonate was selected as the capture technology due to energy efficiency, siting requirements, availability, the possibility to scale up, environmental impact and low risk.
- Calculations show there is potential to capture 800,000tpa.

WHO IS READY FOR CCS?

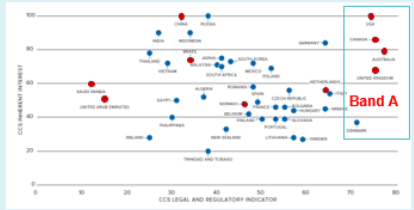
CCS READINESS INDEX

- Established in 2015
- Ranks over 50 countries:
  - Attractiveness for investment and deployment
  - Identifies leaders, fast followers
- Comprises four indicators:
  - Policy
  - Legal
  - Storage
  - Inherent CCS Interest

CCS POLICY INDICATOR



CCS LEGAL & REGULATORY INDICATOR



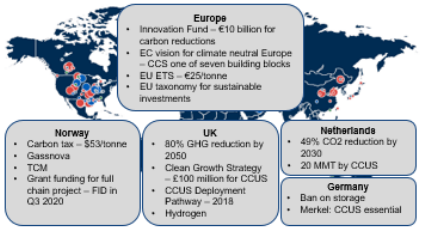
CCS READINESS INDEX

CCS READINESS INDEX

POLICY DEVELOPMENTS

Global
- Paris Accord – 10+ NDCs indicate CCS, Article 6
- Green Climate Fund – funding for CCUS projects
- ICAO – Carbon Offsetting and Reduction Scheme
- London Protocol amendment – bi-lateral agreements

POLICY DEVELOPMENTS



Europe
- Innovation Fund – €10 billion for carbon reductions
- EC vision for climate neutral Europe – CCS one of seven building blocks
- EU ETS – €25/tonne
- EU taxonomy for sustainable investments

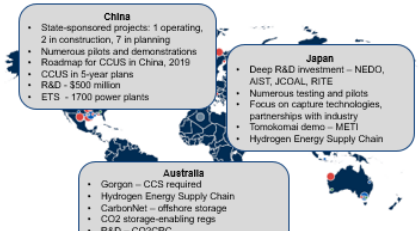
Norway
- Carbon tax – $53/tonne
- Gassnova
- TCM
- Grant funding for full chain project – FID in Q3 2020

UK
- 80% GHG reduction by 2050
- Clean Growth Strategy – £100 million for CCUS
- CCUS Deployment Pathway – 2018
- Hydrogen

Netherlands
- 49% CO2 reduction by 2030
- 20 MMT by CCUS

Germany
- Ban on storage
- Merkel: CCUS essential

POLICY DEVELOPMENTS



China
- State-sponsored projects: 1 operating, 2 in construction, 7 in planning
- Numerous pilots and demonstrations
- Roadmap for CCUS in China, 2019
- CCUS in 5-year plans
- R&D - $500 million
- ETS - 1700 power plants

Japan
- Deep R&D investment – NEDO, AIST, JCOAL, RITE
- Numerous testing and pilots
- Focus on capture technologies, partnerships with industry
- Tomokomai demo – METI
- Hydrogen Energy Supply Chain

Australia
- Gorgon – CCS required
- Hydrogen Energy Supply Chain
- CarbonNet – offshore storage
- CO2 storage-enabling regs
- R&D – CO2CRC
- National Energy Guarantee

THANK YOU

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Questions & Thank You!

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