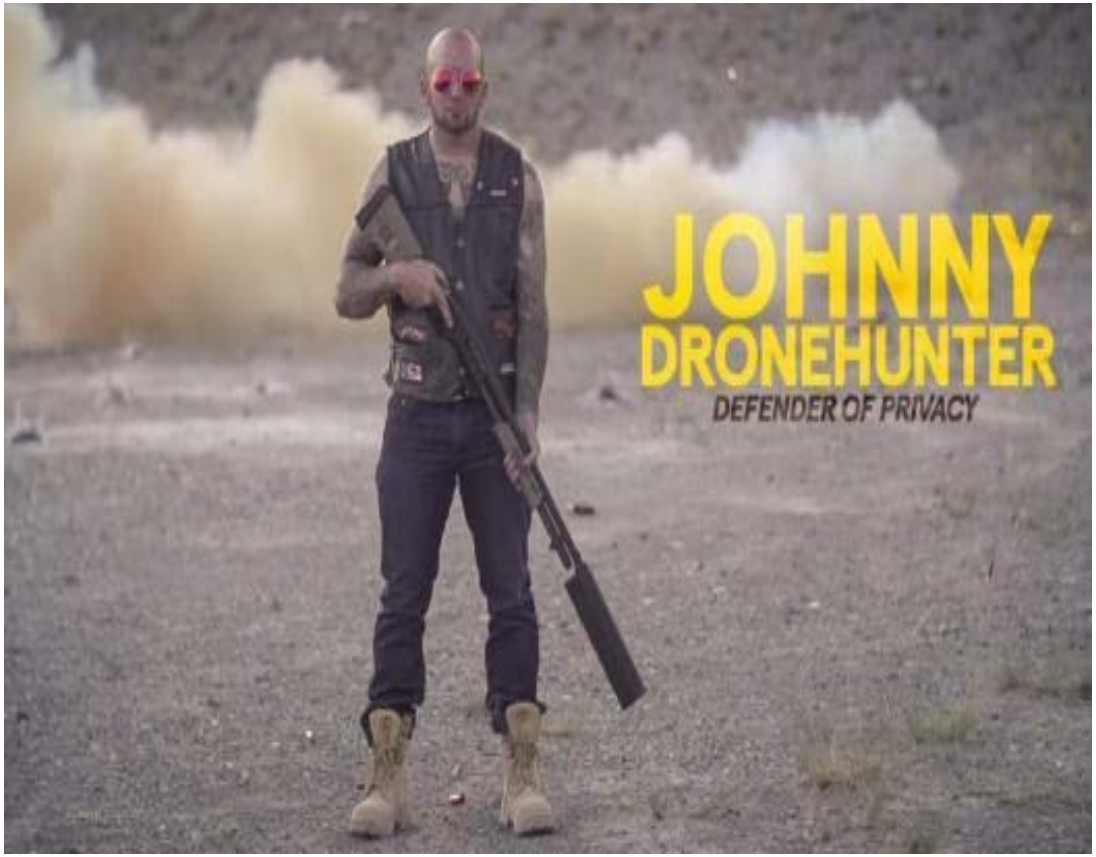
Recap "12th Annual CO_2-EOR Carbon Management Workshop"

Michael E. Moore
Program Director for the Workshop
Thursday December 11th
20th Annual CO_2 Conference
Midland, Texas

Adapting to Changing Situations…



Man Shoots Down Drone, Lawyers Scratch Their Heads---Is it wrong to shoot a robo-trespasser? 10-2-2014 www.popsci.com/article/technology/man-shoots-down-drone-raises-legal-questions?src=SOC&dom=tw

Practical Solutions……

- NGO's consider methane gas from livestock a major contributor to global warming……
- So researchers in Argentina are experimenting with ways to meter and capture the gas from cows.
- In this case directing the gas from their stomachs out into a chamber strapped on their backs.
- Low carbon milk?

http://uk.reuters.com/article/idUKN08306302200807 08

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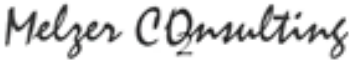


8:00-8:45 Opening of Program Michael Moore NACCSA/FearnOil Inc. and Steve Melzer-Melzer Consulting & APTA with Pre-keynote insights: "New Strategies While Waiting on CO_2"

8:45-9:15 Opening Keynote Speaker-Latest on the "Size of the Prize and the ROZ" Vello Kuuskraa President and COB of Advanced Resources Intl. www.adv-res.com

9:15-9:45 TCEP- Summit Power Updates and Additional Projects Eric Redman President Summit Power Group LLC www.summitpower.com

9:45-10:15 NRG-Petra Nova Parish CCUS Project Texas Latest Developments David Greeson Vice President, Development Petra Nova www.nrg.com/carboncapture & Kenji Hagiwara, Sr. Reservoir Engineer JX Nippon Oil Exploration (U.S.A.) Ltd. (WA Parish Petra Nova CCUS Project partner) www.nex.jx-group.co.jp/english/newsrelease/2014/20140908_01.html

10:15-10:35 Current Status of MHI CO_2 Capture Plant Technology and Commercial Experiences Takashi Kamijo Mitsubishi Heavy Industries America, Inc. www.mhi-global.com/products/category/co2_recovery_plants.html

10:35-10:50 Networking Break

10:50-11:10 Latest Developments at the EERC and CO_2 in the Bakken Shale for EOR. John Harju Associate Director for Research at the EERC www.undeerc.org

11:10-11:30 Federal, State and International Overview: Kipp Coddington General Counsel NACCSA and Partner Kazmarek Mowrey Cloud Laseter LLP www.naccsa.org & www.kmcllaw.com

11:30-12:00 Insights on CO_2-EOR and Geologic Storage. Dwight Peters President-Schlumberger Carbon Services http://www.slb.com/services/additional/carbon.aspx

12:00-1:30 Luncheon Keynote luncheon speaker- Trends in Hydrocarbon Commodity Development Dr. Michelle Foss Chief Energy Economist and Program Manager Bureau of Economic Geology's Center for Energy Economics Jackson School of Geosciences www.beg.utexas.edu/energyecon

1:30-1:50 A World View on CCUS and its Applications/Developments/Value Proposition Charles McConnell Executive Director, Energy and Environment Initiative (e2i) www.eei.rice.edu

1:50-2:10 Highlights and Recent Developments from the Southern States Energy Board. Ken Nemeth Executive Director SSEB www.sseb.org

2:10-2:30 Monitoring and Surveillance Aspects of the first CO_2 Sequestration Project in Saudi Arabia. Modiu Sanni & Sunil Kokal Reservoir Engineering Tech Team EXPEC Advanced Research Center Saudi Aramco www.aramco.com

2:45-3:15 Global CCUS Developments. Neil Wildgust Principal Manager - Geological Storage Global CCS Institute www.globalccsinstitute.com

3:15-3:45 The CCP3 Collaboration Project – Main Achievements and Forward Plans. Nigel Jenvey, Carbon Solutions Manager, BP Group Technology & Chairman of CCP www.bp.com & www.co2captureproject.org

3:45-4:15 Enhanced Oil Recovery and CO_2 Resource Studies at the USGS. Peter Warwick Project Chief www.usgs.gov

4:15-4:45 U.S. EPA's Underground Injection Control Program: Class VI Geologic Sequestration Rule Implementation. Mary Rose "Molly" Bayer Co-Leader for the Geologic Sequestration Team of the Drinking Water Protection Division, Office of Ground Water and Drinking Water US EPA. The primary contact for the Geologic Sequestration UIC Class VI rule and its implementation. US EPA www.epa.gov

4:45-5:00 "Preparing for CO_2 Flooding: How to Monitor and Optimize Waterflood Performance Using a Data-driven Modeling Approach" Srikanta Mishra, Institute Fellow and Senior Research Leader, Battelle Memorial Institute www.battelle.org

5:00-5:15 GHG Permitting in Texas. Scott Deatherage Partner Gardere LLP www.gardere.com

5:15--- Workshop Overview and Insights Panel: Michael Moore-FearnOil/NACCSA, Steve Melzer-APTA, Scott Wehner-Chaparrall and Doug McMurrey-KinderMorgan.

6:30 Workshop Reception

Steve Melzer-Melzer Consulting & APTA with Pre-keynote insights: "New Strategies While Waiting on CO_2"

Strategies While Awaiting CO_2

Outline of Talk

- Focus: EOR as the Large Volume User of CO_2
  - A Quick Historical Look at the Phases of CO_2 EOR
- What is Holding Back Further Growth of CO_2 EOR and CCS?
- A Geeky Look Beyond the Current Business Issues: Let's Examine Emerging Ideas, Trends and What That May Say about Future Markets – Four Key Areas
  1 - CO_2 EOR Moves Below the Oil/Water Contact (ROZ Developments)
  2 - The Unconventional Revolution
  3 - Hydrofracturing the Upper ROZ
  4 - Working More Closely with the Unconventional Reservoir Sub-Industry
    - Produced Water Management
    - NGL By-product Market Making

What's New?

Area #1: Expansion of CO_2 Flooding Below the Oil/Water Contact (into Residual Oil Zones)

Area #2: CO_2 Flooding the Unconventional Reservoirs

Area #3: Producing MPZs & ROZs While Waiting for Affordable CO_2

Area #4: Converting the Produced Water to a Range of Valued Water Products (aka Water Utilization)

What Can be Done to Keep the Momentum and While EOR Awaits New Affordable Supplies?

- Encourage the U.S. DOE to Keep Charging on Deployment of CO_2 Capture Technologies and the CCUS Partnerships
- Defang the Class II to VI Transition Rule Mess
- Examine Horizontally Drilling the Upper ROZ Option to Aggregate the Acreage and Provide Profitability in the Short Term
- Couple the Unconventional Drilling Water Requirements and Growing Aversion to Proliferating Water Disposal Permits with the Emerging Technologies for Water Processing and Water Production During EOR

The Evidence is Everywhere – the CCUS and Oil/Gas Industry's Creative Juices are Flowing

- Unconventional Reservoir Exploitation
- Residual Oil Zone Identification and CO_2 EOR Exploitation
- Upper ROZ Play with Horizontal Wells
- New Ideas for CO_2 Capture
- Better Understandings of CO_2 Retention During EOR
- Produced Water Reutilization
- CO_2 Enhanced ***Product*** Recovery
  - Converts a Waste Gas (CO_2) to a Commodity Fluid
  - Produces Oil
  - Produces Water Products (10# Brine, Frac, Drilling & WAG Water, Fresh Water)

So Here we Go: Getting Moving into an Age of Deployment

Melzer CO_2nsulting

Opening Keynote Speaker "The Prize (ROZ) Becomes Larger" Vello Kuuskraa President and COB of Advanced Resources Intl.

New Resources for a New Age of Hydrocarbons

Conventional onshore and offshore oil and gas have served, and still serve, as the foundation for the world's hydrocarbon supplies.

However, in my view, the world's supply of hydrocarbons is in the midst of a major transition - - a transition from today's comfortable, though increasingly challenging, conventional supplies to a "brave new world" of even more challenging unconventional resources.

Successfully making this transition - - by E&P companies and hydrocarbon producing countries alike - - will require a "step change" in the availability of scientific knowledge and the access to advanced extraction technologies.

Transition from Conventional to Unconventional Hydrocarbons

Two countries - - notably the U.S. and Canada - - who draw on unconventional resources for significant portions of their oil production - - have already made this transition.

- ***U.S. Shale and Tight Oil/Enhanced Oil Recovery***. Shale and "tight" oil, from the Bakken, the Eagle Ford, the Permian and other plays and basins, provide 3.7 million barrels of crude oil per day. Enhanced oil recovery provides 0.8 MMB/D. Together these sources account for more than half of today's U.S. crude oil production of 8.5 MMB/D.
- ***Canada's Oil Sands, Tight Oil and Enhanced Oil Recovery***. With continued development of oil sands, augmented by CO_2, hydrocarbon miscible and thermal enhanced oil recovery, Canada today produces 80% of its crude oil from "unconventional" sources.

Total ROZ "Fairway" Resources: Four Counties of the Permian Basin

The ROZ "fairway" oil in-place in the four county area of the Permian Basin totals 107.1 billion barrels.

- More than half, 66.5 billion barrels, of the ROZ "fairway" resource is higher quality, having an oil saturation greater than 25% and porosity greater than 8%.
- The remaining portion, 40.6 billion barrels of the ROZ "fairway" resource, is lower quality, having an oil saturation less than 25% and/or porosity less than 8%.

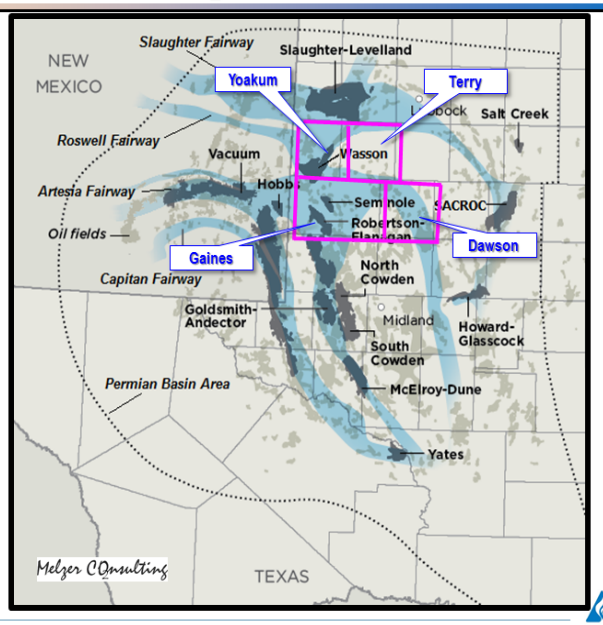
Use of additional logs and data points would, no doubt, modify the above resource assessment values.

Mapping of Residual Oil Zone Fairways in the Permian Basin and Active Major CO_2 EOR Projects

The four county ROZ "fairway" resource assessment addresses the Slaughter and Roswell Fairways on the northern portion of the Permian Basin, where they merge with the Artesia Fairway.

A series of major oil fields - - Wasson, Seminole, Robertson, among others - - are located within these four counties.

The areas underneath the structural closure of these fields have been excluded from the ROZ "fairway" resource assessment.



TCEP- Summit Power Updates and Additional Projects Eric Redman Co-Chairman Summit Power Group LLC

Texas Clean Energy Project: Update & Additional Projects

Eric Redman, Co-Chairman
Summit Power Group, LLC

12th Annual CO_2 EOR Carbon Management Workshop
Midland • December 9, 2014

TCEP Timeline

- 2009: Site selected near Odessa – site had been finalist for FutureGen
- 2010: DOE award under Clean Coal Power Initiative; begin Front-End Engineering & Design (FEED) Study; begin permitting & contract negotiations; first indication of potential Chinese participation in TCEP
- 2011: Signed lump-sum turnkey (LSTK) EPC contracts with Linde (chemical block) and Siemens (power block); complete permitting; work with European export finance agencies to get project loan
- 2012: In mid-year, switch to Chinese EPC contractor as lead for Chemical Block, and to Export-Import Bank of China for project debt
- 2013: EPC contractors "refresh" LSTK pricing; because of boom in Texas construction market, new LSTK pricing is too high for financing
- 2014: Project updated/revised to cut costs; new lead EPC contractor (HQC) selected; EPC contracts restructured so Texas-based EPC team is responsible for constructing entire plant; PPA with CPS Energy renegotiated; new DOE milestones established and are being met

Summit's Plans for Gasification-Based CCUS Projects in 2015

- Complete financing of TCEP and start construction
- Commence design and permitting of CCEP
- Celebrate both events here at next year's CO_2 Conference in Midland!

TCEP Signing Ceremony: US-China Strategic & Economic Dialogue: Summit, HQC, US DOE, Chinese Gov't (NEA), Siemens, CH2M

The "Long Play:" A North Sea Example of CO_2/EOR Possibilities

The Long Play refers to a sustained effort to develop:

- An entire integrated system, consisting of
- Clustered CO_2 capture projects (not just one project),
- Sharing a common CO_2 pipeline and offshore infrastructure,
- In order to produce low-carbon electric power to replace the UK's coal plants (which are slated for closure within 15 years), and
- To store carbon in depleted North Sea gas fields and saline formations, while also
- Creating a CO_2 for enhanced oil recovery (EOR) sector in the North Sea, with its own secure geological storage of CO_2.

Summit's proposed Caledonia Clean Energy Project (CCEP) is intended to anchor the Long Play.

Petra Nova Carbon Capture and Enhanced Oil Recovery Project

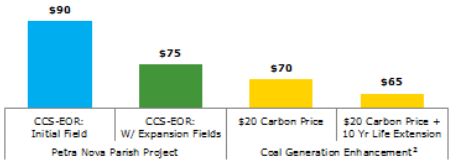
David Greeson & Kenji Hajiwara

Why Did NRG Invest In This Project?

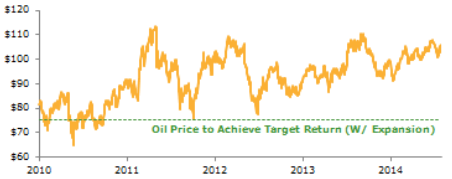
And what's the Value Proposition

- **Commodity Diversification Through Oil / Natural Gas Price Arbitrage**
- **Carbon Price Hedge**
- **Enhance Value and Useful Life of Coal Fleet**
- **Fight Climate Change While Preserving Critical System Fuel Diversity**

Illustrative Oil Price for Target Return[1] ($/bbl)



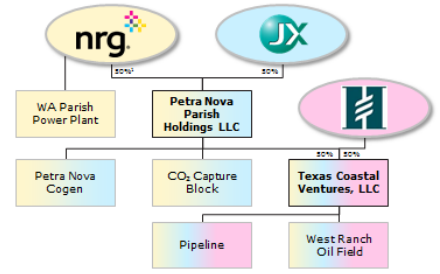
Historical WTI Crude Oil Prices ($/bbl)[1,3]



Our Partners

and the Transaction Structure

Project Ownership Structure



Sources	$MM
NRG Equity[2]	$300
JX Nippon Equity	300
Project Financing	250
DoE Grant	167
Total	**$1,017**

Uses	$MM
Parish Site Capital[2]	$637
Oilfield and Pipeline Capital	300
Initial O&M, G&A, Fees, Other	80
Total	**$1,017**

Partner Summary

Hilcorp Energy

- One of the largest privately-held oil and natural gas E&P companies in the US
- Strong track record of implementing new production techniques into mature reservoirs
- Specialized team that has extensive experience implementing CO_2 floods

JX Nippon Oil & Gas Exploration

- Currently conducting oil and natural gas businessin 14 countries
- Parent company, JX Holdings, is a leading integrated energy, resources, and materials company

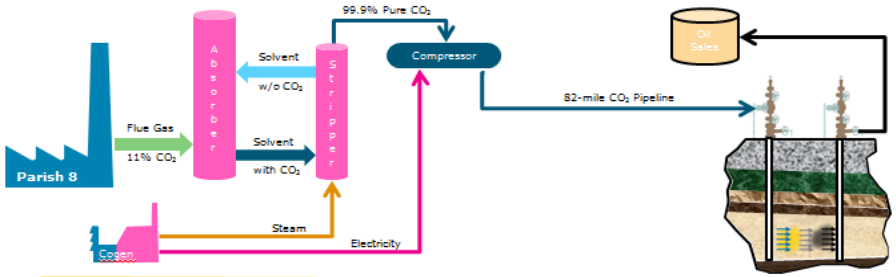
Japan Bank for Int'l Cooperation

- Policy-based financial institution
- Wholly-owned by the Japanese government
- Over 25,000 loan and equity commitments valued at over $479 billion

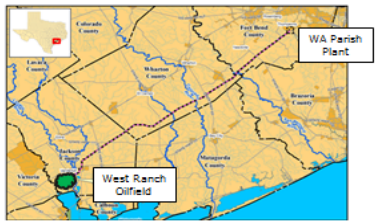
US DoE

- Awarded $167 MM grant
- Funded through Clean Coal Power Initiative

Project Facilities Overview

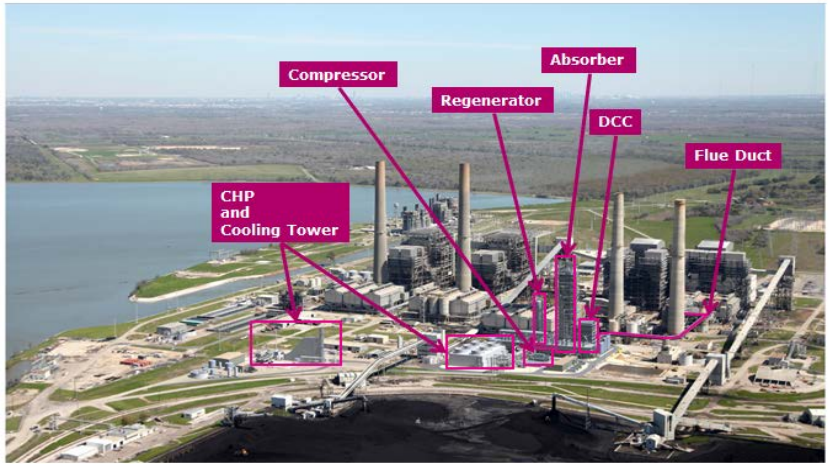


W.A. Parish Plant Site and CCS Configuration



Pipeline Route

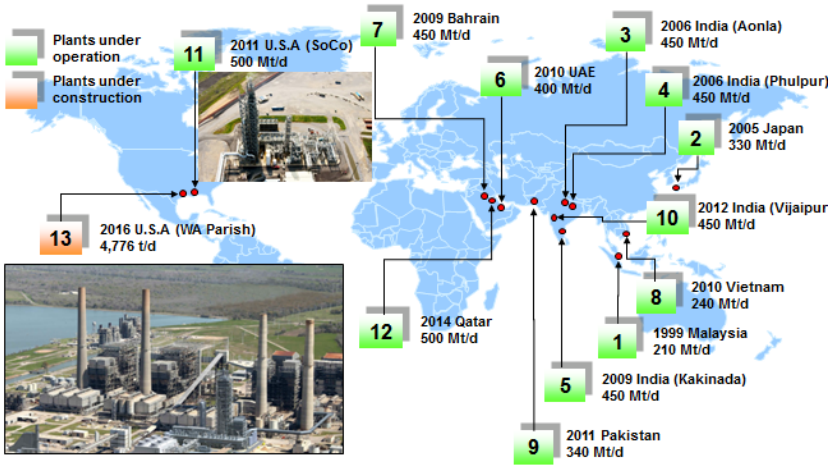
Artist's Rendering



Current Status of MHI CO2 Capture Plant Technology and Commercial Experiences Takashi Kamijo Mitsubishi Heavy Industries America, Inc.

MHI CO2 Capture Reference Plants

MHI is a World leading LARGE-SCALE post combustion CO_2 capture technology licensor, with 11 commercial PCC plants in operation



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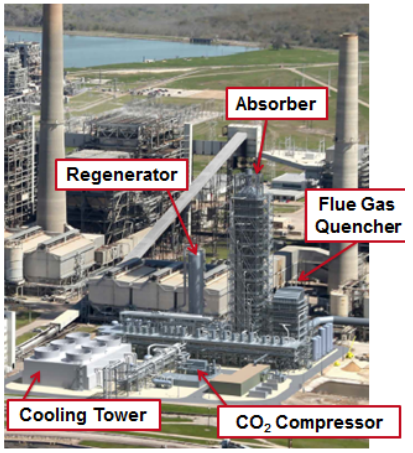
CO_2 Capture Plant for CO_2-EOR

The worlds largest CO_2 capture plant from an existing coal-fired power plant

- Project owner: NRG Energy Inc. and JX Nippon Oil & Gas Exploration Corporation
- Location: NRG WA Parish Power Plant near Houston, TX.
- Flue gas source: 240MWe slipstream from an existing 650MW coal-fired boiler
- CO_2 concentration: 11.5%
- CO_2 capture capacity: 4,776 TPD
- CO_2 recovery ratio: 90%
- CO_2 Use: Enhanced Oil Recovery (EOR)
- Transport: 12 inch diameter pipeline, Approximately 81 miles
- Injection Site: West Ranch oil field in Jackson County, TX
- Operation Start: 4th Quarter, 2016



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500 Metric TPD Integrated CCS Demo PJ (1/2)

<Project Overview>

- CO_2 Capture and Compression
  - SCS/MHI collaboration with partners
  - KM-CDR® capture technology
- Transportation and Sequestration
  - DOE SECARB Phase III "Anthropogenic Test"
  - 12 mile CO_2 pipeline to Citronelle Dome
- World's First CCS Project integrated with Amine-based Post Combustion Process and CO_2 Injection

<Operation Status>

- Gas In for CO_2 Capture Plant: June, 2011
- CO_2 injection started on August 20th, 2012
- 100,000 metric tons of CO_2 injection was achieved as of October 29th, 2013

Items		Results
Total Operation Time *	hrs	12,400
Total Amount of Captured CO_2 *	metric tons	230,100
Total Amount of Injected CO_2 *	metric tons	115,500

*As of August 31th, 2014

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Reference: Denbury, "SECARB - Plant Barry to Citronelle", Knowledge Sharing Conference – Mobile, May 17, 2012

Summary

- MHI can provide cost competitive and reliable CO2 capture plant from flue gas based on our abundant commercial experiences
- Southern Company's Plant Barry 500 TPD CCS plant has successfully completed its 2nd year of operation
- MHI has started to construct the world largest CO_2 capture and compression plant near Houston, Texas for NRG Energy Inc. and JX Nippon Oil & Gas Exploration Corporation
- CO_2 capture from flue gas can contribute to global warming issue and useful for CO_2 EOR

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Latest Developments at the EERC and CO_2 in the Bakken Shale for EOR. John Harju Associate Director for Research at the EERC

Bakken CO_2 Storage and Enhanced Recovery Program

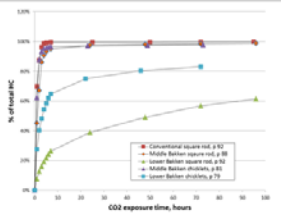
Phase II Partners

Continental Resources · NETL · Kinder Morgan · North Dakota DMR · Marathon Oil · Schlumberger · CMG Computer Modeling Group Ltd. · XTO Energy · Baker Hughes · Hess

Lab-Scale CO_2 Extraction of Oil from Tight Rocks (Bakken)

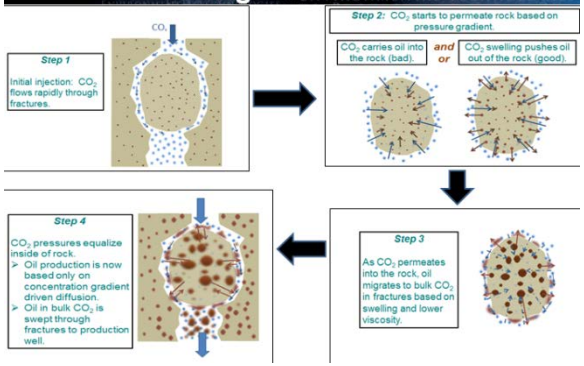
CO_2 extraction of oil from samples of Middle and Lower Bakken rock.

5000 psi, 110°C (230°F) – examine effect of "unit cell" rock size and matrix lithology.



- Over 90% from Middle Bakken.
- Over 60% from Lower Bakken shale.
- Primary mechanism is likely diffusion.

CO_2 Extraction of Oil from Tight Rocks



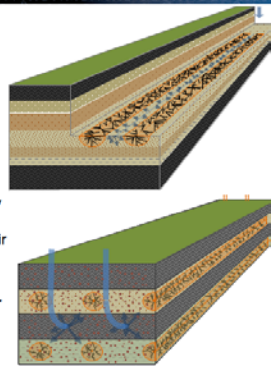
Bakken CO_2 EOR and Storage Capacity Potential

The U.S. Department of Energy (DOE) methodology for estimating CO_2 EOR and storage capacity (Carbon Sequestration Atlas of the United States and Canada, 2007) was applied to the Bakken:

- Preliminary estimate suggests that the demand to fully apply EOR in the Bakken is **2 to 3.2 billion tons of CO_2**.
- This would yield **4 to 7 billion barrels** of incremental oil.
- Potential sources of CO_2 in North Dakota may include:
  - Coal-fired power plants.
  - Dakota Gasification Company's Great Plains Synfuels Plant.
  - Refineries.
  - Natural gas-processing plants.
  - Ethanol plants.
  - Extension of Denbury Resources, Inc., pipeline from Wyoming gas plants.

"Take Home" Thoughts

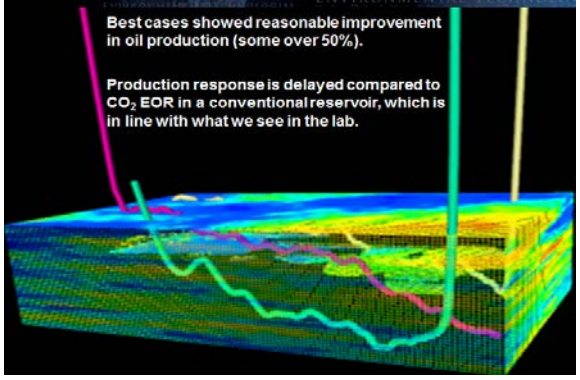
- Unconventional resource will take unconventional approach to EOR.
  - Diffusion is more important than displacement.
  - Patience required, but reward may be substantial.
- Innovative injection and production schemes.
  - Use unfractured wells as injectors; rely on natural fracture system for slower movement of CO_2 through the reservoir and improved matrix contact time.
  - Injectors in the shale paired with producers in the Middle Bakken and/or Three Forks.



Simulation Results Highlights

Best cases showed reasonable improvement in oil production (some over 50%).

Production response is delayed compared to CO_2 EOR in a conventional reservoir, which is in line with what we see in the lab.



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World Wide Web: **www.undeerc.org**
Telephone No. (701) 777-5157
Fax No. (701) 777-5181

Federal, State and International Overview: Kipp Coddington General Counsel NACCSA and Partner Kazmarek Mowrey Cloud Laseter LLP

INTERNATIONAL: THE 2015 PARIS AGREEMENT

Long-term and collective aspects of mitigation

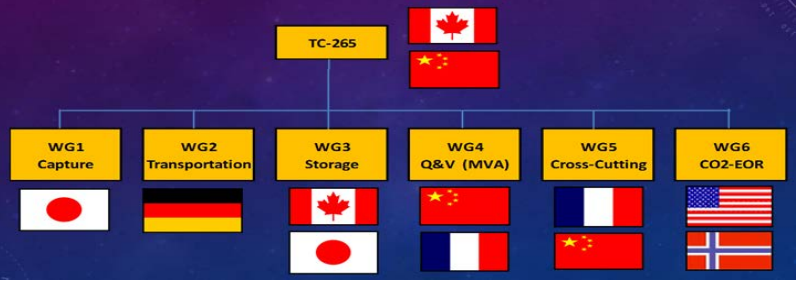
- Mitigation commitments/contributions in aggregate to contribute to emission reductions consistent with the agreed limit to global temperature rise
- A long-term common goal to be expressed:
  - As a limit to global average temperature rise below 2/1.5 °C above pre-industrial levels
  - As a maximum concentration of GHGs in the atmosphere
  - As a global goal for emission reductions
    - In the form of a trajectory to reach 50 per cent below 1990 levels by 2050
    - In line with science (e.g. 40–70 per cent below 2010 levels by 2050 with net emissions near zero, or below zero, by 2100); as carbon neutrality by the end of the century; and by 2050 for developed countries
  - As a carbon budget: atmospheric space and development space to be divided among Parties
- Mitigation and adaptation to achieve a net decrease in emission levels

Source: "Parties views and proposals on the elements for a draft negotiating text," Ad Hoc Working Group on the Durban Platform for Enhanced Action (July 7, 2014)

THE 2015 PARIS AGREEMENT: WHAT TO EXPECT

- Effective 2050-2100 decarbonization pathways
  - *CCS/CCUS/CO_2-EOR implicitly necessary*
  - *Oil, natural gas and coal targeted*
- New U.S. commitments by 1Q 2015
- Draft treaty text by spring 2015
- Treaty text likely agreed by December 2015 (Paris)
- Senate ratification likely not required

INTERNATIONAL: CCS AND CO_2-EOR/STORAGE STANDARDS UNDER DEVELOPMENT



FEDERAL DEVELOPMENTS

- Legislation on Section 45Q
- Draft EPA Guidance on Transition from Class II to VI
  - *Future uncertain*
- New Source Performance Standards for New EGUs
  - *Expected to require EOR to opt into Subpart RR of the GHG Reporting Rule (MRV)*
  - *Likely to be issued in January 2015*
  - *Expect litigation, including Class EOR/VI arguments*

STATE DEVELOPMENTS

- California
- Social Cost of Carbon in PUC Proceedings
  - *Minnesota*
- Carbon State Implementation Plans under the Section 111(d) Rule
  - *Federal Implementation Plans possible, maybe even likely*
- CO_2-EOR as "Best Available Control Technology" for Prevention of Significant Deterioration Permitting under the Clean Air Act
  - *Natural gas separation plants*
  - *LNG export terminals*
  - *Refineries*
  - *Power plants*
  - *Ethanol plants*
  - *Etc.*

IMPACTS FOR PROJECT OWNERS, OPERATORS & DEVELOPERS

The oil and gas industry has been successfully and economically recovering CO_2 from natural gas pretreatment plants and using it for EOR for over 35 years. The technologies and operational practices for treating, transporting, and injecting CO_2 for EOR are well developed and are very similar to those that would be required to capture CO_2 from Freeport's Pretreatment Facility CO_2 stream. "These technologies are considered readily transferable and applicable to CCS…"[48] While most CO_2 used for EOR has been extracted from naturally occurring sources, there are several CCS projects that use CO_2 produced from natural gas and other similar nearly pure CO_2 waste streams, including many in Texas' Permian Basin. Some of these projects are summarized in Table 3:

Table 3
Commercial EOR Projects Using Anthropogenic Carbon Dioxide[79]

USA

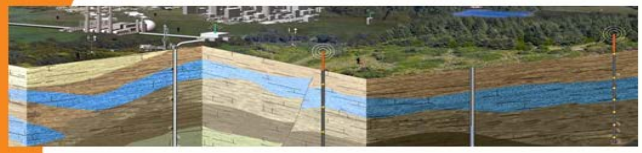
Project	Leader	Location	CO_2 Source	Size Mt/yr	CO_2 Sink	Status
Val Verde	Multiple operators	Texas	Gas Processing	1.3	EOR	Operational 1972
La Barge	Exxon Mobil	Wyoming	Gas Processing	6	EOR	Operational 1986

- ✓ 109 references to EOR over 49 pages
- ✓ Litigation over permits, MRV plans and the like can be expected

Source: "Comments of the Sierra Club on the PSD Permit for the Freeport LNG Liquefaction Project" (January 6, 2014)

CO_2-EOR and Carbon Storage. Dwight Peters President-Schlumberger Carbon Services

Schlumberger Carbon Services



CO_2-EOR and Carbon Storage

Dwight Peters

9 Dec 2014

www.slb.com/carbonservices

The Carbon "Mindset" of People Advocating:

Schlumberger Carbon Services

CO_2-EOR	Carbon Storage
• A means to an end	• Permanence
• Economic good	• Safety
• Energy security	• Accountability
• Efficient use of resources	
• Incidental storage	
• "Been doing it for 40 years"	

The Rules are Different

Schlumberger Carbon Services

Difference	CO_2-EOR	Carbon Storage
Classification	Class II	Class VI
Area of Review	~ ¼ mile	10's of miles
• Different Definition		
Permanence	MIT	Monitoring program
Quantifiability	None	Reports (models)
Permit timing	Relatively short	Years
Well age	10's of years	New
# wells	Many	<10?
Reservoir pressure	Same or lower	Higher

Lessons Learned Through Demonstrations

Schlumberger Carbon Services

- Geologic sequestration is scary to many "sources"
- CO_2 tends to move farther and faster than models can predict
- Can monitor CO_2
  - No chance of 100% accounting
- Old wells need special attention
  - Biggest risk in old oil fields
  - Would make it virtually impossible for Class VI standards
- Study the public mood before speaking to them

Luncheon Keynote Speaker- Trends in Hydrocarbon Commodity Development Dr. Michelle Foss Chief Energy Economist and Program Manager Bureau of Economic Geology's Center for Energy Economics Jackson School of Geosciences

- Iraq's massive oil resources may be the target of rapidly dropping oil prices…
- Several ME producers are financially secure at the lower prices
- Expect rationalization of current business models
- EPC, materials, labor and energy costs dropping
- Looks similar to drop in the '90's
- May be some time before prices get back above $100/bbl for crude oil

A World View on CCUS and its Applications/Developments/Value Proposition Charles McConnell Executive Director, Energy and Environment Initiative (e2i)

- It is “CCUS”!!!
- CCUS represents a responsible way to mitigate CO_2 emissions
- Time to “vote for” rather than “vote against” processes that work/support CCUS
- Get behind “game-changers” in technology
- More $$ for CCUS research and deployment

Highlights and Recent Developments from the Southern States Energy Board. Ken Nemeth Executive Director SSEB

CO_2-EOR & Carbon Management: Highlights and Recent Developments

Kenneth J. Nemeth

Executive Director & Secretary, Southern States Energy Board

Presented to:

12th Annual (2014) EOR Carbon Management Workshop
December 9, 2014
Midland, Texas

Presentation Outline

- About Southern States Energy Board (SSEB)
- Energy & Environmental Challenges to GHG Emissions Reductions: International, National, and Regional Perspectives
- Recent Government Frameworks to Incentivize Industry to Utilize CO_2 for EOR and Beyond
- Southeast Regional Carbon Sequestration Partnership
- Upcoming SSEB Events

Background

Through innovations in energy and environmental policies, programs and technologies, the Southern States Energy Board enhances economic development and the quality of life in the South.
- SSEB Mission Statement

- Established 1960, expanded in 1978
- 16 U.S. States and Two Territories
- Each jurisdiction represented by the governor, a legislator from the House and Senate and a governor's alternate
- Federal Representative Appointed by U.S. President

SECARB Phase III

SECARB
Southeast Regional Carbon Sequestration Partnership

EPRI ELECTRIC POWER RESEARCH INSTITUTE

Anthropogenic Test
Capture: Alabama Power 's Plant Barry, Bucks, Alabama
Transportation: Denbury
Geo Storage: Denbury's Citronelle Field Citronelle, Alabama

Early Test
Denbury Resources' Cranfield Field Near Natchez, Mississippi
CO_2 Source: Denbury
CO_2 Transportation: Denbury
Saline MVA: GCCC

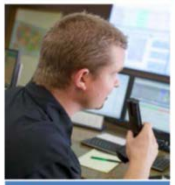
Gulf Coast Carbon Center

SECARB · NETL · EPRI · SOUTHERN COMPANY · Denbury

CCUS + EOR Drives Job Creation, Economic Growth in 2030

The National Coal Council
Power for America from America

Powerlines, Pipelines, EOR, and CTL = Economic Comeback



$60 billion
Annual Tax Revenues

$188+ billion
Sales

1,000+ thousand
Jobs

Mark Your Calendar!

Dates of Meeting*	SSEB Meetings	Location of Meeting
February23, 2015	SSEB Associate Members Winter Meeting (held in conjunction with the National Governor's Association Winter Meeting)	Washington, DC
March 2015	Southeast Regional Carbon Sequestration Partnership 10th Annual Stakeholders Briefing	Atlanta, Georgia
May18-19, 2015	SSEB Coal and Advanced Power Systems Committee Meeting (held in conjunction with the Virginia Coal and Energy Alliance's Annual Meeting)	Kingsport, Tennessee
July 18, 2015*	SSEB 2015 Legislative Briefing (held in conjunction with the Southern Legislative Conference Annual Meeting)	Savannah, Georgia
August 20, 2015*	SSEB Associate Members Summer Meeting (held in conjunction with the Southern Governors' Association Annual Meeting)	St. Louis, Missouri
September 27-29, 2015*	SSEB 55th Annual Meeting	White Sulphur Springs, West Virginia

**NOTE: Dates are subject to change for certain meetings.*

Kenneth J. Nemeth

Executive Director & Secretary, Southern States Energy Board

6325 Amherst Court | Peachtree Corners, Georgia 30092
(770) 242-7712 | (770) 242-9956
nemeth@sseb.org
www.sseb.org

Monitoring and Surveillance Aspects of the first CO_2 Sequestration Project in Saudi Arabia. Modiu Sanni & Sunil Kokal Reservoir Engineering Tech Team EXPEC Advanced Research Center Saudi Aramco

ارامكو السعودية
Saudi Aramco

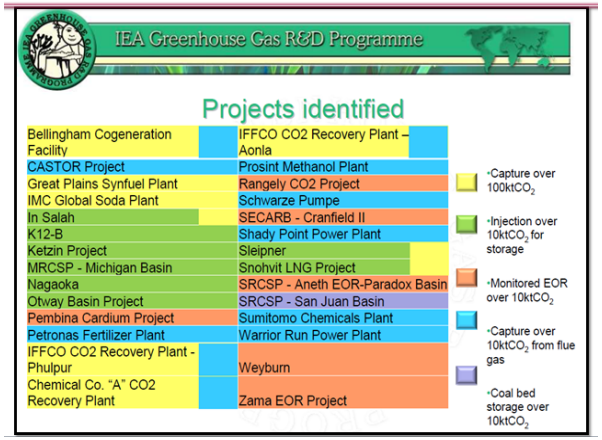
Monitoring and Surveillance Aspects of the First CO2-EOR Sequestration Project in Saudi Arabia

Modiu Sanni & Sunil Kokal
Saudi Aramco

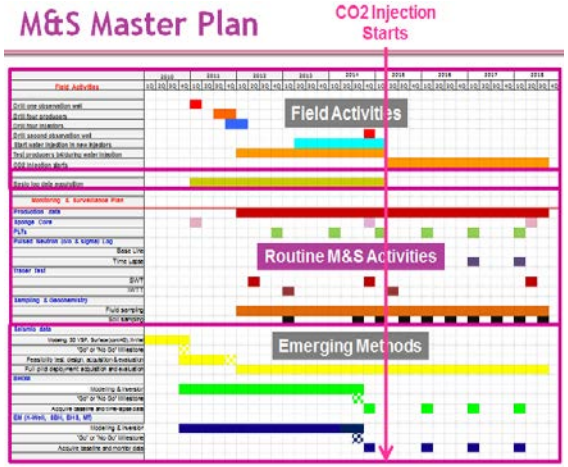
Objectives

- Project Objectives:
  - Clear assessment of CO_2 potential (EOR and Storage)
  - Assess key risks & uncertainties
- Monitoring & Surveillance Objectives
  - Obtain data to evaluate demo project
  - Understand recovery & storage mechanisms
  - ID operational issues & concerns for FFD
  - Evaluate the efficacy/efficiency of CO_2-EOR sequestration process
  - Build public confidence (CCS-political)

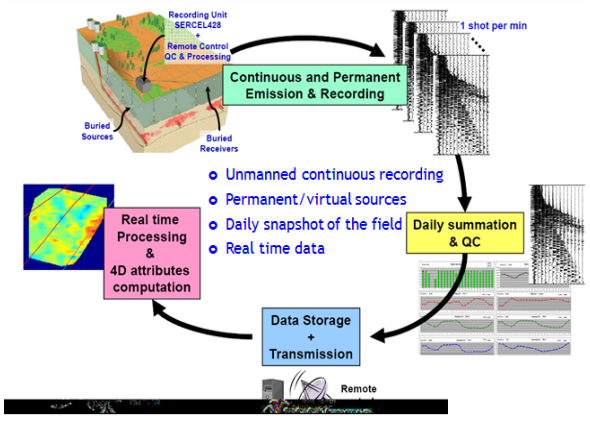
Lessons Learned From Other Projects



M&S Master Plan



Significant Step Towards Next Generation i-Field



Global CCUS Developments. Neil Wildgust Principal Manager - Geological Storage Global CCS Institute

GLOBAL CCS INSTITUTE

GLOBAL CCUS DEVELOPMENTS

2014 EOR CARBON MANAGEMENT WORKSHOP – MIDLAND, TEXAS

Neil Wildgust
9th December 2014

The Global CCS Institute

- We are an international membership organization.
- Headquarters in Melbourne.
- **Regional offices serving the Americas**, Europe-Africa-Middle East, and Asia Pacific.
- Our diverse international membership consists of:
  - governments,
  - global corporations,
  - small companies,
  - research bodies, and
  - non-government organisations.
- Specialist expertise covers the CCS/CCUS value chain.

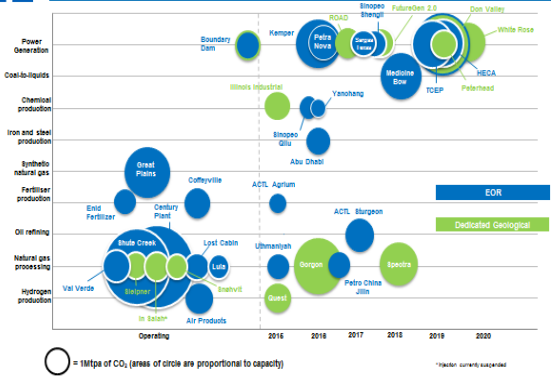
The Global Status of CCS: 2014

The *Global Status of CCS: 2014* – Key Institute publication

This year's report:

- Provides a comprehensive overview of global and regional developments in large-scale CCS projects, in CCS technologies and in the policy, legal and regulatory environment.
- Introduces and links to project descriptions for around 40 lesser scale 'notable' CCS projects.
- Makes recommendations for decision makers.
- The full report is available online, including supporting resources and data http://www.globalccsinstitute.com/

Actual and expected operation dates for projects in operation, construction and advanced planning



2014-2015 is a watershed period for CCS – it is a reality in the power sector and additional project approvals are anticipated

CCUS PROJECTS IN CHINA

Project	Start	Capture	CO_2 Mt/annum	Storage
Sinopec Qilu	2016	Gasification	0.35 – 0.5	EOR (Shingli Oil Field)
Sinopec Shengli	2017	Post-combustion coal power	1.0	
Shaanxi Yangchang	2016	Gasification	0.46	EOR (Ordos Basin)
Petrochina Jilin	2016	Natural Gas processing	0.8	EOR (Jilin Oil Field)
Greengen	*2015*	*Gasification*	*0.06 – 2.0*	*EOR & Saline*

Our call to action for 2015

It is time to move the agenda forward:

- CCS in the power sector is now a reality
- We now have 50% more projects than at the start of the decade
- Next generation CCS needs decisions now
- We must all take today's messages and promote CCS
- Challenge is not technology – it is policy and support
- CCS community must build on recent successes

OUR CALL TO ACTION IS TO ACCELERATE CCS AROUND THE WORLD

The CCP3 Collaboration Project – Main Achievements and Forward Plans. Nigel Jenvey, Carbon Solutions Manager, BP Group Technology & Chairman of CCP

CO_2 Capture Project®

The CCP3 Collaboration Project – Main Achievements & Forward Plans

Presented by Nigel Jenvey[1], CCP3 Chairman

[1]BP Group Technology, 501 Westlake Park Blvd, Houston, TX 77079, USA

CO2 Conference
Midland TX, Tuesday 9th December 2014

CCP3 "Demonstrate technologies that will reduce the cost and accelerate deployment of CCS"

"Field/plant access for pilot/demo's"

"Project Delivery Focus"

"Mid TRL level technology development"

"Company Expert Collaboration"

CCP1
2000-2004
Screening/proof of concept

CCP2
2004-2009
Intensive development

CCP3
2009-2014
Demonstration phase

"Independent Verification of Cost and Performance"

"Global network of external partners"

"Technology Agnostic"

"Effectively managed and run"

CCP3

The application of CCP insights to CCUS

- Separation & Capture
  - Supply of CO_2 from a range of oil and gas industry scenarios
  - Finding and validating low cost CO_2 capture (flue gas) technologies
  - Finding and validating lower cost CO_2 separation (feed gas) technologies
  - Advancing CO_2 Metering, Compression, and Transportation technologies
- Utilization & Storage
  - Validating that CO_2 can be safely and securely stored
  - Developing and trialing surveillance and monitoring technologies
  - Assessing & predicting existing well integrity
  - Providing tools that can help regulatory site certification
  - Understanding the science of fundamental subsurface processes

CCP3

Capture Program

Refinery Scenario

- Field demonstration of Fluid Catalytic Cracking (FCC) oxy-firing capture technology at Petrobras, Brazil
- FCC is one of the main sources of oil refinery CO2 emissions (20-30%)
- Aim: to evaluate operability, test start-up, shut down procedures and obtain data for scale-up

Heavy Oil Scenario

- Capture from multiple Once Through Steam Generators (OTSGs) in the Canadian oil sands has been studied in CCP3
- Cases were designed to provide the same amount of useful injection steam as the reference case

Image courtesy of Cenovus

CCP3

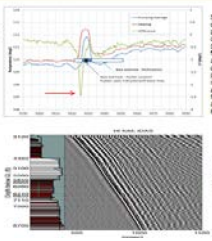
SMV Program

SMV Program – Themes

- **Well Integrity** – Stability of well barrier function with geomechanical and geochemical alteration
- **Subsurface Processes** – Physicochemical interactions that affect storage assurance
- **Monitoring & Verification** – Retrospective performance of past deployments and decision support; Technology development
- **Optimization** – Risk-based analysis of storage program development, economics of CO_2 EOR/storage and EGR utilization challenges in unconventionals
- **Field Trialing** – Deployment and performance analysis of new and adapted monitoring technologies at third party field sites
- **Contingencies** – Detection, characterization and intervention in unexpected CO_2 migration through top/fault seals

SMV Program – Field Trialing

- Time-Lapse TCR and RST – comparability of pre-flood, open hole resistivity and post-flood TCR logs to infer saturation [T. Dance, CO2CRC/CSIRO; A. Datey, Schlumberger]
- Borehole Gravity – Resolution and reproducibility at Cranfield [SECARB; CSM, LBNL]
- Decatur – Remote detection capability
  - InSAR [G. Falorni, TRE-Canada]
  - GPS [T. Dixon, U Florida]
- Modular Borehole Monitoring system
  - Design (Design) [T. Daley et al., LBNL]
  - Deployment (Citronelle) [SECARB, LBNL, EPRI, ARI]
- Downhole to surface EM evaluation at Aquistore [LBNL, Groundmetrics,]
- Soil Gas Monitoring Method [K. Romanak, UT-BEG]



CCP4 "*Advancing CCS technology deployment and knowledge for the oil and gas industry*"

CCP1
2000-2004
Screening/proof of concept

CCP2
2004-2009
Intensive development

CCP3
2009-2014
Demonstration phase

CCP4
2014-2019
Further Advancement

CCP4

Enhanced Oil Recovery and CO_2 Resource Studies at the USGS.
Peter Warwick Project Chief

USGS

Enhanced Oil Recovery and CO_2 Resource Studies at the U.S. Geological Survey

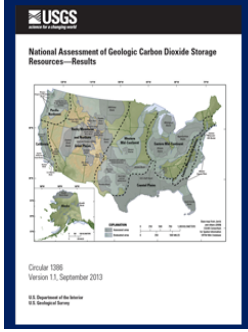
P. D. Warwick and U.S. Geological Survey Geologic Carbon Dioxide Storage Resources Assessment Team

The 12th Annual (2014) EOR Carbon Management Workshop – Midland, Texas
Part of the Annual CO_2 Conference Week December 8-12, 2014

U.S. Geological Survey
Department of the Interior

USGS National Assessment of Geologic Carbon Dioxide Storage Resources

by U.S. Geological Survey Geologic Carbon Dioxide Storage Resources Assessment Team, 2013a,b,c



Three companion assessment reports:

a. Data - USGS Data Series 774: http://pubs.usgs.gov/ds/774/

b. Results - USGS Circular 1386: http://pubs.usgs.gov/circ/1386/

c. Summary - Fact Sheet 2013–3020: http://pubs.usgs.gov/fs/2013/3020/

Carbon Sequestration – Geologic Research and Assessments (*2014 – 2018*)

Task 1: Methodology development and assessment of national CO_2 enhanced oil recovery (CO_2-EOR) and associated CO_2 storage potential

Task 2: Geological studies of reservoirs and seals in selected basins with high potential for CO_2 storage

Task 3: Natural CO_2 and helium resources and analogues for anthropogenic CO_2 storage

Task 4: Economics of CO_2 storage and enhanced oil recovery

Task 5: Storage of CO_2 in unconventional geologic reservoirs

Task 6: Induced seismicity associated with CO_2 geologic storage

Task 7: Outreach

Methodology development and assessment of national CO_2 enhanced oil recovery and associated CO_2 storage potential

- Requested by Energy Independence and Security Act
- Goal is to develop a probabilistic assessment methodology and then estimate the technically recoverable (pre-economic) hydrocarbon potential using CO_2-EOR within the United States
- The recoverable hydrocarbon volume occupies potential pore space that may be available for sequestration of anthropogenic CO_2 in subsurface hydrocarbon reservoirs

USGS Activities to Implement a National Helium Assessment

- USGS and BLM are in the process of building a combined DOI natural gas geochemical database that could be used for a national assessment of helium resources. The database will include both national and international data on helium occurrence in geologic formations. An on-line, map-based data portal is being designed.
- A request for State participation was made at the 2014 annual meeting of the Association of American State Geologists to contribute to the natural gas geochemical database. Several State geological surveys are compiling data to be incorporated in the database.
- USGS and BLM plan to work together to assess *discovered* and *undiscovered* national CO_2 and helium resources.

Summary

- The USGS is developing a probabilistic assessment methodology and then will estimate the technically recoverable hydrocarbon potential using CO_2-EOR within the United States
- Natural CO_2/helium studies are now underway in various parts of the United States to better understand total carbon dioxide/helium systems
- The USGS is building a national geochemical database that can be used to evaluate the occurrence and distribution of He and CO_2 resources occurring in natural gas reservoirs in the country
- The USGS welcomes the opportunity to sample gas wells that are producing >10 percent CO_2

USGS

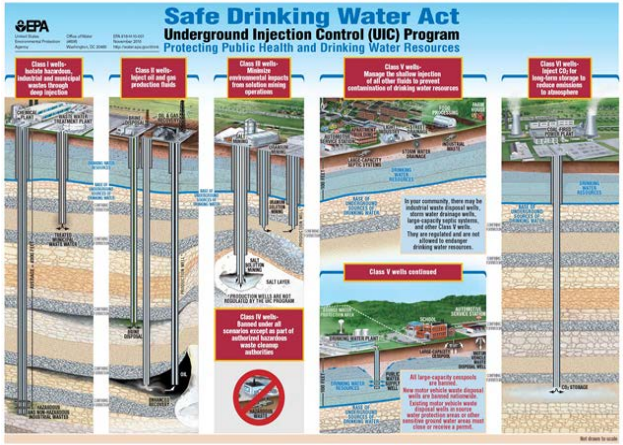
USGS science for a changing world

Peter D. Warwick
pwarwick@usgs.gov
703-648-6469

http://energy.usgs.gov

http://go.usa.gov/8X8 (USGS geologic CO_2 project website)

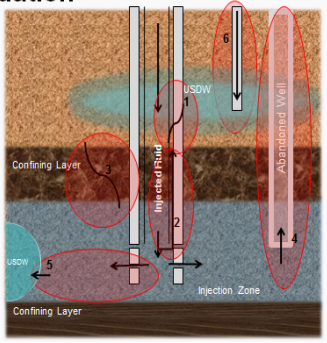
U.S. EPA's Underground Injection Control Program: Class VI Geologic Sequestration Rule Implementation. Mary Rose "Molly" Bayer Co-Leader for the Geologic Sequestration Team of the Drinking Water Protection Division, Office of Ground Water and Drinking Water US EPA.



UIC Program Foundation

Potential Fluid Migration Pathways

1. Faulty injection well casing
2. Annulus between casing and the well bore
3. Migration through confining layers from injection zone
4. Vertical migration through improperly abandoned and completed wells
5. Lateral migration from within injection zone into a protected portion of a USDW
6. Direct injection of fluids into or above a USDW



Class VI Rule

Considerations for GS
- Large Volumes
- Buoyancy
- Viscosity (Mobility)
- Corrosivity

UIC Program Elements
- Site Characterization
- Area of Review (AoR)
- Well Construction
- Well Operation
- Site Monitoring
- Post-Injection Site Care
- Public Participation
- Financial Responsibility
- Site Closure

New well class established in 2010: Class VI

Class VI Rule

- Timeline:
  - Development announced: 2007
  - Proposed: July 2008
  - Notice of Data Availability: August 2009
  - Finalized: December 2010
- Voluntary (i.e., under the UIC Program, there is no mandate to inject CO_2)
- Coordinated with other EPA initiatives and in consultation with Federal Partners, States and Stakeholders

Class VI Implementation

- Implementation Activities
  - Implementation workshops
  - Guidance development
    - Technical Guidance addressing Site Characterization, Area of Review Delineation, Well Construction, Testing and Monitoring, Post-Injection Site Care and Site Closure, Transitioning from Class II to Class VI
    - Financial Responsibility
    - Primary Enforcement Responsibility
  - Permitting
  - Stakeholder coordination

Class VI Implementation: Permitting

- *Application In Review*: Berexco, LLC
  - Location: Wellington, KS
  - Total *proposed* injection volume: 40,000 tons of CO_2
  - *Proposed* total project duration: 17 months
    - Nine months of injection
    - One year of post-injection site care
  - CO_2 source: TBD
- *Anticipated*
  - Region 8: Big Sky Partnership, Kevin Dome, MT

Class VI Implementation: Permitting Goals

- Comprehensively evaluate project information to:
  - Confirm that a geologic sequestration well or wells will be sited, operated, monitored and closed in a manner that ensures USDW protection
  - Ensure a complete, clear, science-based and defensible decision making process (documented in an Administrative Record)
  - Facilitate communication regarding EPA actions and decision-making with the permittee, co-regulators and the public
- Ensure:
  - Specificity
  - Consistency
  - Certainty
  - Confidence

Class VI Implementation: Permitting

- Archer Daniels Midland Project
  - Location: Decatur, IL
  - Total proposed injection volume: 6.5 million tons of CO_2 (via two wells)
  - Proposed total project duration: 18 years
    - 8 years of injection (3 years at CCS #1; 5 years at CCS #2)
    - 10 years of post-injection site care
  - CO_2 source: An ethanol plant converting biomass (i.e., corn stover) into ethanol
- FutureGen Alliance Project
  - Location: Jacksonville, IL
  - Total proposed injection volume: 22 million tons of CO_2 (via four wells)
  - Proposed total project duration: 70 years
    - 20 years of injection
    - 50 years of post-injection site care
  - CO_2 source: Retrofit of the existing (retired), Meredosia coal-fired power plant with an oxy-combustion technology to allow CO_2 capture

Stakeholder Coordination

Federal Partners
- Department of Energy
  - Pacific Northwest National Laboratory (PNNL)
  - Lawrence Berkeley National Laboratory (LBNL)
- Department of Interior (i.e., USGS; BLM; BOEM)
- CCS Task Force Participants
- Internal Revenue Service

State-Level Partners
- States
- Ground Water Protection Council
- Interstate Oil and Gas Compact Commission
- Association of American State Geologists

Others
- Non-governmental and environmental organizations
- Industry organizations and representatives
- Academia
- Public stakeholders

Class VI Implementation: Class II and Class VI

- Final Class VI Rule included requirements at 40 CFR 144.19 designed to address potential, future injection operation scenarios where a well ***may*** transition from Class II to Class VI
- Draft guidance posted for public comment in December 2013
- March 2014 – Present
  - Evaluating written comments
  - Meeting with/hearing from stakeholders
  - Identifying ways to increase clarity and certainty in a final guidance
  - Engaging in Inter- and Intra-Agency coordination

"Preparing for CO_2 Flooding: How to Monitor and Optimize Waterflood Performance Using a Data-driven Modeling Approach"

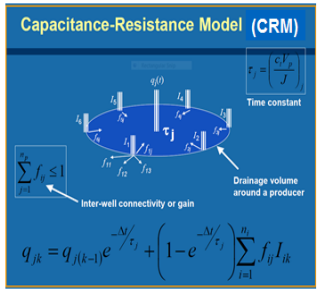
Srikanta Mishra, Institute Fellow and Senior Research Leader,
Battelle Memorial Institute

Key Takeaways

- Basic premise ⇨ Best predictor of a good CO_2 flood is a good waterflood
- Challenge ⇨ How to optimize a waterflood using only injection and production data?
- Solution ⇨ Data-driven approach based on historical waterflooding data
- Who benefits ⇨ Very useful for small operators who do not have the resources to build a full geological model
- Outcomes ⇨ Improve performance during the waterflood and prepare the reservoir for an efficient CO_2 flood

Our Data-Driven Approach (CRM)

- Based on simple mass balance and flux continuity
- Uses only rates and bottom-hole pressures
- Two parameters
  - Gain ⇨ fraction of an injector's rate that flows towards a specific producer
  - Time constant ⇨ time required for producer to respond to step input change in injector
- No geologic model needed



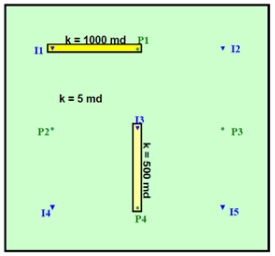
Sayarpour et al., 2007, SPE 110081

What are the Steps in Modeling?

- CRM parameters are determined by calibrating the model to historical water injection and total fluid production data
- Oil production rates are matched using an empirical water-cut model
- This history matched model can then be used to optimize the allocation of injection rates which maximizes oil recovery
- Typical constraints are: maximum net present value, minimum water cut, specified cumulative water injection, target voidage ratio, etc.
- A robust optimization approach has been developed, building upon our experience in real-time control of mechanical systems

Optimized v/s Non-Optimized Results

- Specified constant total injection rate used as constraint
- Goal is to maximize cumulative oil production



	Non-Optimized case	Optimized case
I1 rate (rb/d)	1808	
I2 rate (rb/d)	1142	
I3 rate (rb/d)	1192	
I4 rate (rb/d)	759	4038
I5 rate (rb/d)	930	1793
Cum oil (rb)	524,000	668,000

Practical Considerations

- Method has been applied by large companies as a screening step prior to full-field simulations
- Our enhancements to the original algorithm
  - Improved empirical modeling of water-cut
  - Time biasing to give more weight to most recent data
  - Sensitivity to choice of optimization metric (e.g., NPV, water cut, cum oil production, cum injected volume)
  - Robust optimization with ability to handle multiple objectives
  - Options for data filtering and aggregation

Summary

- CRM-based modeling approach powerful tool for data-driven waterflood optimization in ongoing projects
- Captures physics of subsurface flow processes
- Provides useful insights regarding
  - preferential flow paths in the reservoir
  - desirable injection-production configurations
- Helps in optimizing the design of future EOR operations such as CO_2 injection or chemical flooding
- Limited data needs make it attractive for small producers

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GHG Permitting in Texas. Scott Deatherage Partner Gardere LLP

EPA Greenhouse Gas Permitting Program in Texas

- EPA Promulgates Tailoring Rule under Federal Clean Air Act to Allow Permitting under Prevention Of Deterioration (PSD) Program and Title V of the Clean Air Act (CAA)
  - Rule provided only larger emissions sources addressed initially-thus "tailored" rule to larger sources of GHG emissions
- Texas Refuses to Implement Federal GHG Permitting Program through State Implementation Plan (SIP), Objects to EPA Regulating Greenhouse Gas (GHG) emissions
- EPA Issues Federal Implementation Plan (FIP)
  - EPA Region 6 in Dallas begins reviewing GHG Permits for projects in Texas, But Fails to Hire Sufficient Staff to Handle Workload

Texas Practical Dilemma

- Permit Applications Begin to Pile up at EPA Region 6 in Dallas
- 10-20 Billion Dollars Worth of Projects in Texas Not Able to Start Construction without GHG Permit, Resulting in Major Bottle Neck for Texas Economy
- In 2013, Industry Lobbies Texas Legislature to Pass Legislation to Require TCEQ to Take over Federal GHG Permitting Program from EPA
- 2013/ 2014 EPA-TCEQ Working to Transition Program to TCEQ
  - TCEQ proposed rules to implement GHG permitting in Texas
  - EPA-TCEQ Negotiations Over Rules

Obtaining Permits During the EPA-TCEQ Transition

- EPA and TCEQ Negotiated Work Share Program Whereby TCEQ Processes Much of Permit Prior to Transition of Program To Texas
- First Group of Permits Worked by TCEQ, Reviewed and Issued by EPA Region 6, Which Allowed More Permits to Be Issued and Began to Reduce Backlog
- EPA Proposes Rule to Allow Delegation of GHG PSD Permitting Program to Texas and Withdrawal of Federal Implementation Plan (FIP) by Which EPA Was Implementing the GHG PSD/Title V Permitting Program in Texas
- Effective Nov. 10, 2014, EPA Issued Rule Allowing Texas to Implement the GHG PSD/Title V Program in Texas

CCS and GHG Permitting: TCEQ Will Be Required to Review CCS under BACT

- Under Prevention of Deterioration (PSD) Program, Case-by-Case Evaluation of Best Available Control Technology (BACT)
- Step 1 – Identify all available control technologies.
- Step 2 – Eliminate technically infeasible options.
- Step 3 – Rank remaining control technologies.
- Step 4 – Evaluate and document remaining control technologies.
- Step 5 – Select BACT.

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Current Process with TCEQ Reviewing GHG Emission Permits

- Eliminated and Stream Lined Air Permitting Process for Large Projects and Reduced Time to Obtain Permits Required to Start Construction of New or Modified Sources Subject to GHG Permitting Requirements
- Key Element of the Texas Legislation: Exempted the TCEQ GHG Permitting Process from Contested Case Hearing
- Issue for Future GHG Permitting:
  - EPA set unrealistic economic thresholds for CCS--$ per ton of GHG emissions controlled
  - Problem: If new technology drops costs below that level, but not to a level that actually allows economic CCS, then could create difficulty in obtaining GHG permits for larger emissions sources

Carbon Trading Law and Practice, published by Oxford University Press, 2011
http://www.oup.com/us/catalog/general/subject/Law/EnvironmentalLaw/EnergyandNaturalResourceLaw/?view=usa&ci=9780199732210/

Workshop Overview and Insights Panel: Michael Moore-FearnOil/NACCSA, Steve Melzer-APTA, Scott Wehner-Chaparrall and Doug McMurrey-KinderMorgan.

Questions & Thank You!

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