CO$_2$ EOR (& CCS) “Potpourri” *

Steve Melzer
Melzer CO$_2$nsulting
Midland, Texas

* Def:  1. A mixture of dried petals and spices—
      2. A mixture of things  ✔
      3. Literal: a pot of rotten things  I hope not
Outline of Talk

• A Quick Historical Look at the Phases of CO₂ EOR
• What is CO₂ Worth Today? Have Constrained CO₂ Supplies Slowed EOR Deployment?
• A Quick Look at the Rockies and the Permian Basin CO₂ Markets
• Maximized Prices: So Where are the CO₂ Capture Projects?
• The “Gap” in what CO₂ is Worth and What it Costs to Capture it
• Working on the “Gap”: Who’s Trying to Help? Who’s Not?
• CO₂ Policy: U.S. and International – Is the Gap too Big for Clean Coal?
• So Much for the Business Issues: Let’s Finish by Getting Geeky: The Latest in ROZ Developments
The Phases of CO₂ Enhanced Oil Recovery

PERMIAN BASIN CO₂ EOR PROJECT STARTS
PB Undersupplied Since 2004
Okay, So We’re Undersupplied, We all Know it Takes Time for New Supplies to Come to the Market.....

But Maybe it is Not Just Time that is the Problem, Let’s Talk about the “GAP”
CCS – Deep Saline Formation Injection Model

Cost of Capture

Cost of Clean Air – Waste Injection Model.
The ‘Gap’ (CCU.S. View)

\( CO_2 \) EOR Enters the Picture

Cost of Capture

The “Gap”

Value of the \( CO_2 \) in the U.S.
The Developing World’s View of the ‘Gap’

*Environmental Value Included*

- Cost of Capture
- Environmental Value of CO₂ Capture
- Desired Value of the CO₂ for EOR in Asia
So What is the Real Value of CO$_2$ in CCU.S.?

Let’s look at the Two Most Mature Areas of CO$_2$ EOR in the World:

The Permian Basin and The Rockies
Rockies Supply/Demand...
The Oversupply Crossover Point is Later in Time but Present Now

So What Have the CO$_2$ Prices Done?
PB to Rockies: Area Differences in CO$_2$ Pricing
(at the Source Field)

LaBarge (WY) Comparison to McElmo (Permian Basin) CO$_2$ Pricing

- McElmo Reference Price
- LaBarge Ratio of Price to McElmo CO$_2$ Price

5-year Ave. 77%
Within the PB: Wellhead Price Differences (at the Source)

Bravo Dome Comparison to McElmo CO₂ Pricing in the Permian Basin

% of McElmo Price

Year

2009 2010 2011 2012 2013

Bravo Ratio of Price to McElmo CO₂ Price McElmo Reference Price

5-year Ave. 86%
Who’s Trying to Help Close/Remove the “Gap”?
This is Easy...

The List Isn’t All That Long

• Department of Energy
• CO₂ ‘Generators’ in the Capture Industry
• Some Environmental Non-Gov’t Organizations
• The National Enhanced Oil Recovery Initiative (NEORI)
The U.S. Department of Energy Attacks the “Gap”
Re-imagining RD&D Priorities for a Decade of Deployment
Exchange Monitor’s CarbonSQ conference
April 29th, 2014, Pittsburgh, PA

Dr. S. Julio Friedmann
Deputy Assistant Secretary
Office of Clean Coal
### Brief history and roadmap for CCS

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<td>• Niche commercial efforts</td>
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<td>• Much knowledge gained</td>
<td>• “Commercial toolbox” developed</td>
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<td>• 1930’s and 1970’s tech for capture</td>
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<td>• Major tech development</td>
<td>• Dramatic cost reductions</td>
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<td>• Little known for storage</td>
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<td>• Tools being developed and tested</td>
<td>• 1000’s of sites worldwide</td>
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<th>Storage Infrastructure/Field Tests</th>
<th>Then: Little known outside of oilfield services</th>
<th>Now: Increased visibility; Knowledge gained and lessons learned</th>
<th>Future (2030): Market frameworks in place</th>
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<tr>
<td>• Sleipner project initiated</td>
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<td>• 12 large projects world-wide</td>
<td>• Novel regulatory mechanisms</td>
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DOE CCUS Demonstration Projects

Focus – Large-scale commercial demonstration of CCUS integrated with coal power generation and industrial sources.

- **Hydrogen Energy California**
  - IGCC with EOR
  - $408 Million - DOE
  - $4.0 Billion - Total

- **FutureGen 2.0**
  - Oxy-combustion with CO₂ capture and saline storage
  - $1.0 Billion - DOE
  - $1.3 Billion - Total

- **Summit Texas Clean Energy**
  - IGCC with EOR
  - $450 Million - DOE
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- **NRG Energy**
  - Post Combustion with CO₂ Capture with EOR
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- **Air Products**
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- **Southern Company Services**
  - IGCC-Transport Gasifier w/CO₂ pipeline
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- **Archer Daniels Midland**
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- **Leucadia**
  - CO₂ Capture from Methanol with EOR
  - $261 Million - DOE
  - $436 Million - Total

**Legend**
- **FutureGen**
- **CCPI**
- **ICCS (Area I)**
LPO Has More than $40 Billion in Remaining Loan Authority

*Includes nuclear generation and front-end nuclear projects.

**Imputed loan authority. Actual loan volume will depend on actual credit subsidy rates for projects.
Four Key Eligibility Requirements for Advanced Fossil Projects

**Innovative Technology**
The project must employ new, or significantly improved, technology as compared to commercial technologies in service in the United States.

**U.S.-Based Projects**
The project must be located in the United States.

**Reduce Greenhouse Gases**
The project must avoid, reduce, or sequester anthropogenic emissions of greenhouse gases.

**Financial Viability**
The project must assure a reasonable prospect of repayment of principal and interest.

*complete eligibility requirements can be found in the Final Solicitation*
And, There is also
The National Enhanced Oil Recovery Initiative (NEORI) Attacking the “Gap”
Capitol Hill Briefing: An Energy, Economic and Environmental Solution for Our Nation

by NEORI on JUNE 23, 2014

Please join
The Honorable Richard Gephardt,
The Honorable Tim Hutchinson,
and experts for
a Capitol Hill Briefing:

An Energy, Economic and Environmental Solution for Our Nation:
Using Captured Carbon Dioxide for Enhanced Oil Recovery

Thursday, June 26, 2014
Rockefeller bill would expand carbon dioxide EOR tax credits

WASHINGTON, DC, May 5
05/05/2014
By Nick Snow
OGJ Washington Editor

US Sen. John D. Rockefeller IV (D-W.Va.) introduced legislation that would increase tax credits for using carbon dioxide in enhanced oil recovery, and establish a certification process to help future projects obtain financing.

Growth of the CO₂ EOR industry depends upon capturing substantially more CO₂ from manmade sources, the senator said on May 5. “Authorized to only provide tax credits for 75 million tons of CO₂, the existing 45Q program is insufficient to take advantage of CO₂-EOR’s potential,” he maintained. “Already, tax credits have been claimed for 21 million tons, and the remaining pool of tax credits likely will be exhausted in the next several years.”

The bill also would establish periodic reviews of the CO₂ sequestration credit under Section 45Q of the federal tax code and provide the US Treasury Secretary authority to ensure that new tax credits would be revenue positive to the federal government over time when taking into account the revenue produced from increased oil recovery resulting from the credit compared with tax revenue lost from credits being claimed, Rockefeller said.

According to the National Energy Technology Laboratory (NETL), increasing the supply of CO₂ captured from manmade sources has the potential to increase American oil production by tens of billions of barrels, while safely storing billions of tons of CO₂ underground, the senator added.

He introduced his Expanding Carbon Capture through Enhanced Oil Recovery Act alongside another bill, the Carbon Capture and Sequestration Deployment Act, which would authorize $1 billion over 15 years for a cooperative industry-government research and development program in the US Department of Energy’s Fossil Energy Office.
NEORI Bill

- SB 1234 - Introduced in June 2014
- Justifies a Federal Revenue Positive Capture Incentive for CO$_2$ EOR of $10/tonne (potentially raise more than $80 billion)
- New 45Q tax credits will be allocated:
  - Through separate tranches: electric power, lower-cost industrial, higher-cost industrial tranches; tranches ensure that credits will be allocated to all potential capture sources of man-made CO$_2$
  - Via competitive bidding: in a given tranche, a carbon capture project developer will bid for a certain dollar per tonne level of credit; the lowest bid will win.
  - With credit certification: upon receiving an allocation of tax credits, a project will apply for certification and thus reserve tax credits for use once operational. Projects will be able to take advantage of the certainty of receiving credits when seeking private sector investment.
- To ensure that new 45Q tax credits are allocated in a way that achieves federal revenue goals, S. 1234 tasks the U.S. Treasury with determining whether federal revenue from new CO$_2$ EOR production exceeds the cost of new 45Q tax credits.
  - This determination is made after the seventh round of competitive bidding.
  - If the 45Q program is not expected to be revenue positive, the Treasury will make recommendations to Congress for program improvements.
And Who’s **Not** Helping to Close/Remove the “Gap”?
Geologic Sequestration of Carbon Dioxide

Draft Underground Injection Control (UIC) Program Guidance on Transitioning Class II Wells to Class VI Wells

* http://water.epa.gov/type/groundwater/uic/class6/upload/epa816p13004.pdf
But Before I Opine on The Regulatory Flaws....

“If you Want to Solve a Problem....Let Somebody Make Some Money Solving It”
Change Regulators (and Legal Framework)

Figure 4. Phases of a Hypothetical Oil Production Project that Transitions to ER and Eventually GS, Illustrating Relative Risk.*
From: Benson (2007).

* http://water.epa.gov/type/groundwater/uic/class6/upload/epa816p13004.pdf
The determination of the need for a Class VI permit is based on risk to USDWs. In the Class VI Rule, EPA identified several factors that indicate a change in project operations that may increase risks to USDWs. These factors are to be considered by owners or operators and Class VI UIC Program Directors\(^1\) when determining whether a Class VI permit is required for carbon dioxide injection in wells currently permitted as Class II wells. They may also be considered by owners or operators applying for a permit for a Class II well to inform business decisions prior to deciding whether to permit a well as a Class II or Class VI well. Considering these factors ahead of time may also ease the transition process at a later point in time. These factors are established in the Class VI Rule at 40 CFR 144.19(b), and include:

- Increase in reservoir pressure;
- Increase in carbon dioxide injection rates;
- Decrease in reservoir production rates;
- Distance between injection zone and USDWs;
- Suitability of Class II AoR delineation;
- Quality of abandoned well plugs;
- Anticipated recovery of injected carbon dioxide at cessation of injection;
- Source and properties of injected carbon dioxide; and

- Additional factors determined by the UIC Program Director.
Post Injection Site Care and Site Closure (PISC)

4.3.6 Post-Injection Site Care and Site Closure

The Class VI Rule at 40 CFR 146.93 incorporates an extended PISC, which is unique in the UIC Program and not required of other injection well classes. Class VI well owners or operators must prepare, gain approval of, and follow a comprehensive PISC and Site Closure Plan [40 CFR 146.93(a)].

Class VI well owners or operators must perform monitoring and site care following cessation of injection to show the position of the separate-phase carbon dioxide plume and the associated area of elevated pressure [40 CFR 146.93(b)]. This site care, which includes monitoring of groundwater quality and the position of the carbon dioxide plume and pressure front, must continue for a timeframe established in the permit (i.e., the 50-year default or an alternative timeframe established by modeling) or until the owner or operator can demonstrate to the UIC Program Director, based on site monitoring data, that the project no longer poses a risk of endangerment to USDWs.

Ref: http://water.epa.gov/type/groundwater/uic/class6/upload/epa816p13004.pdf
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U.S. DEPARTMENT OF ENERGY
Fossil Energy
Clean Coal Does Have its Challenges but...Before You Think Coal is Dead

Rising German Coal Use Imperils European Emissions Deal

By Matthew Gourley | June 20, 2014 12:00 PM CT |

The European Union’s attempt to cap greenhouse-gas emissions over the next 16 years is threatened again as rising pollution from the bloc’s biggest economies shows even developed nations want to burn cheap coal.

Germany, Europe’s largest economy, boosted consumption of the fuel by 13 percent in the past four years, while use in Britain, No. 3 in the region economically, rose 22 percent, statistics from oil company BP Plc show. While Germany pledged to cut heat-trapping gases 55 percent by 2030 from 1990 levels, it’s managed 25 percent so far and is moving in the wrong direction, according to the European Environment Agency.

The EU is seeking to craft a deal in October that would cut greenhouse gases 40 percent by 2030 in the world’s biggest effort to combat global warming since the Kyoto climate treaty of 1997. Countries including Poland, which relies on coal to generate more than 80 percent of its power, want to guarantee their right to use the fuel before signing off on targets they say penalize lower-income nations.

“Both the U.K. and Germany are on a collision course with Poland,” Maciej Bukowski, president of the Warsaw Institute of Economic Studies, which has advised Poland on greenhouse gas cuts, said by phone June 17. “To cut emissions, it needs to spend a lot of money up front,” he said, predicting a 50 percent chance the October deadline will slip.

Energy Security

Connie Hedegaard, the EU Climate Action commissioner, sought a deal in the first quarter to bolster the EU’s standing at a United Nations world leaders’ climate summit in September. In March, EU politicians delayed agreeing on the 2030 package until October as Russia annexed Ukraine’s Crimea, boosting the bloc’s focus on energy security.

Germany’s emissions rose even as its production of intermittent wind and solar power, climbed fivefold in the past decade. Utilities boosted production from profitable coal-fired plants after Chancellor Angela Merkel decided to close all 17 of the country’s nuclear plants by 2022 in the wake of the Fukushima nuclear disaster in 2011.

Next-year coal for delivery to northwest Europe is down 9 percent this year to $78.75 a metric ton, near the lowest price in five years, according to broker data compiled by Bloomberg.

The U.K. plans to retire all but one of nine atomic generators by 2023, Poland cut its greenhouse-gas output by 14 percent since 1990 as state-owned companies were shuttered during the economic transformation from the communist era.

Reliable Electricity
Enough on those Business/Policy Matters
Let’s Talk Some Technical Stuff
What’s New?

Expansion of Flooding Below the Oil/Water Contact and into Residual Oil Zones
Residual Oil Zone Flooding: Project History and Phases of Development

ROZ Project Starts

- **Observation Phase**
- **Deployment Phase**

(Bennett Ranch Unit)

Seminole and Wasson (Denver Unit)

Year (biennium)

No. of Project Starts

1995 1997 1999 2001 2003 2005 2007 2009 2011 2013
Residual Oil Zone (ROZ) Field Tests

- As of Now, There are 14 individual projects underway in 7 Different Fields
- All Projects are in the Permian Basin (for now at least)
- All Projects are Using CO$_2$ EOR Technology
- All Projects are Flooding the ROZ of the San Andres Formation
- One of these Projects is Flooding a Portion of the Field without a Main Payzone (Greenfield {GF})
- Deployment of ROZ Floods is Accelerating with International Interest Growing
Mapping of Residual Oil Zone Fairways in the Permian Basin and Active Major CO₂ 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.
Four County Study Area of Permian Basin ROZ “Fairway”

The ROZ “fairway” resource assessment covers four West Texas Permian Basin counties - - Yoakum, Terry, Gaines and Dawson.

- The study used an extensive set of log- and core-based reservoir data to estimate the size of the ROZ oil in-place.
- Data were assembled for wells both inside and outside the currently mapped ROZ “fairway” boundaries.
Still A Work in Progress...But

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 more than 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.
Rockies and Other Basins **Very** Probably Have Similar Opportunities

- Bighorn (Pegui’s Talk Later)
- Powder River Basin
- Green River Basin
- Williston Basin
Definitions

Transition Zone (TZ):
- Low oil saturation
- Flows water and little oil
- Capillary forces

Residual Oil Zone (ROZ):
- Produces only water
- Immobile oil
- Structural changes (uplift)

(Koperna et al. 2006; LaCroix et al. 2009)

* SPE 169113 • A Laboratory Study to Investigate CO₂ Potential to Mobilize Paleo Oil
  • Ahmed Aleidan
Summary

• CO₂ EOR Now Has an Exemplary 40-Year History
• New EOR Targets Abound
• Future Could be Very Bright if Storage of CO₂ were Coupled with Incremental Oil Recovery Opportunities

.....But

• CO₂ EOR is in a “Slow Growth” Mode at the Moment
  – Existing CO₂ Supplies are Contracted and Maxed Out
  – New Anthropogenic Supplies Are Challenged to Close the Cost “Gap” and, in addition, Appear to Bring Extra Burdens of Costs Due to EPA Class VI Requirements

• Where is it Going? Are Other Pastures (e.g., Unconventionals) Just too Much Greener? And/or Less Strewn with Politics?
Closing Perspective

• The Evidence is Everywhere – the Oil/Gas Industry’s Creative Juices are Flowing
  – Unconventional Reservoir Exploitation
  – Residual Oil Zones
  – 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 Water, Fresh Water)

• With your Resources Here in this State (Coal, Oil, Natural Gas, Trona and so on), Wyoming and EORI Could be a World Leader
Thank You

Time for Questions?