VALUE ADDED CCS: CO2 EOR AND CO2 ECBM

BOTTOM LINE

The capture of anthropogenic carbon dioxide from point sources and subsequent transportation and injection for secure, long-term geologic storage has become more important as a technology to reduce the effects of global climate change. However, until there are state or federal regulations that require this to be done, carbon capture and storage (CCS) will only be driven by economic incentives, i.e., to produce more oil or more natural gas. Those who desire to take advantage of the convergence of commercial CO2 projects and CCS can draw on the experience of the oil and gas industry, which has a 30-year history of enhanced oil recovery, and a more recent history of enhanced coal-bed methane recovery, both of which employ the injection of CO2.

PROBLEM ADDRESSED

Case studies and success stories presented during the workshop indicate that most of the technical problems associated with injecting CO2 into oil reservoirs to move and produce oil, and ultimately to store CO2, have been resolved. A bigger problem, perhaps, is gaining public and regulatory agency acceptance of the practice. Although industry has a long-term track record of safe injection of CO2, the public and state and federal regulators need assurance that CO2, once injected, will remain in the storage container, and if it does not, that any leakage can and will be detected at the surface or in aquifers.

A technical problem that was addressed is the need to inject CO2 at pressures less than fracture pressure but still high enough to achieve miscibility, i.e., above the minimum miscibility pressure. This is a problem in areas like the Appalachian basin, where Pennsylvanian and Mississippian oil reservoirs commonly occur at shallow depths where miscibility cannot be obtained without fracturing the reservoir. Deeper oil reservoirs, such as those in Upper Devonian sandstones, can achieve miscibility at injection pressures that will not induce fracturing of the reservoir and seal. Other oil reservoirs, at depths between these end members, may be in the “near miscible” zone. The speaker presented several cases where immiscible floods have been implemented and have been successful. Why were they successful? Two possibilities that were suggested are oil swelling and viscosity reduction.

One technical problem associated with injecting CO2 in coal beds also was addressed. When CO2 is injected into coal, it preferentially replaces CH4 molecules that are adsorbed on the cleat surfaces in roughly a 2:1 ratio. This two-fold increase in molecular adsorption along the coal cleats creates a physical change referred to as coal swelling, which reduces permeability to the point that further injection of CO2 cannot be achieved. Typically, this is a near-wellbore condition, so much of the coal between an injection and a production well does not come into contact with injected CO2.

Some operators and researchers are experimenting with combinations of CO2 and N2 in the injection stream. Nitrogen passes easily through the coal from injection to production wells, and has the ability to "carry" CO2 along with it, such that replacement of CH4 by CO2 can occur deeper in the coal reservoir.

TECHNOLOGY OVERVIEW

The workshop was separated into seven segments, beginning with an introduction to enhanced oil recovery and commercial CO2 injection EOR. During this section, the instructor covered definitions of various terms that would be used throughout the day, and introduced participants to miscible and immiscible flooding, enhanced coal bed methane (ECBM), placed CO2 EOR and ECBM within the spectrum of EOR techniques, outlined the necessary components of a CO2 project, and discussed expected incremental production and costs for CO2 EOR.

The second section was a geological overview of existing CO2 EOR projects and a database of these projects. Topics discussed included a history of CO2 flooding; distribution of current CO2 floods; reservoir properties of these floods; current activities related to growth of CO2 floods; and conventional and unconventional CO2 flooding.

Section three was a brief review of enhanced coal bed methane. The instructor gave full credit to Scott Reeves, Advanced Resources International, for providing slides and expertise for this section, which provided a segway into section four, value-added CCS and EOR. During this section, the instructor emphasized the convergence of commercial CO2 projects and carbon capture and storage. A short section on current operational practices followed this section.

Section six was on residual oil zones, especially expanding the scope of floodable intervals beneath the oil-water contact. Topics discussed included hydrodynamic forces and residual oil zone formation ("Mother Nature's waterfloods); hydrodynamic trapping; and distribution of known ROZ intervals and oil in place, with examples.

The final section was on getting started, with an emphasis on cyclic CO2 gas injection. Theory, target areas, application and regional examples were discussed and presented. The instructors credited Bernie Miller for some of the slides and supporting information.

CONNECTIONS

These observations were based on a workshop sponsored by PTTC's Appalachian Region in Morgantown, WV on February 12, 2008.

Speaker:

L. Stephen Melzer, Melzer CO2nsulting, Midland, TX 79702-2083; phone 432-682-7664, e-mail melzerls@aol.com

SUMMARY OF EVALUATION FORMS

Forty two people pre-registered for the workshop, and in spite of very poor weather conditions, 39 attended. Of these, 22 took the time to complete and submit an evaluation form prior to leaving ahead of further bad weather that was moving into the Morgantown area. Only 10 of the 22 were from industry, with the other 12 evenly split between academia and government employees.

Prior to the workshop, we posted the workshop on our website and the PTTC national website, and e-mailed an announcement to the members of our e-mail distribution network. In addition, we e-mailed additional announcements to all members of the Interstate Oil and Gas Compact Commission Task Force on Carbon Capture and Storage; all registrants at a recent Energy Summit on "Advancing Domestic Resources in an Era of Carbon Challenges" hosted by West Virginia Governor Joe Manchin; all Appalachian basin PAG members; and members of a joint U.S.-China research team investigating future energy options that include CO2 sequestration. In addition, we printed and mailed our usual workshop flyer to approximately 1500 former workshop attendees.

Of the 22 people who responded to the question, "How did you hear about the workshop?" 9 received one of the e-mail announcements and 6 received a flyer. One saw the workshop posted on the website and 5 heard of it from other people, i.e., by word of mouth.

Although the vast majority (85%) of attendees was pleased with the workshop content, facility and speaker, a few offered some negative comments. As usual, some of these dealt with continuing heating/cooling problems in the meeting room, while others were more substantial, referring to the organization and length of the various sections of the workshop. Some would have preferred a greater focus on ECBM, or on screening candidate reservoirs for CO2 floods, or a summary of the CO2 floods that have been attempted in West Virginia.

Only a few topics were suggested for future workshops, and only one of these was a follow up on EOR applications specific to this basin. Others made reference to the Marcellus Shale, a topic covered last month, or dealing with water produced in CBM operations. Geophysical topics such as velocity modeling, synthetics, advanced log interpretation and fracture detection were the others.

It was encouraging to note that 13 of the 22 had attended previous PTTC workshops, and 6 of these indicated that they have implemented something that they learned at one of our workshops. Four indicated they were willing to share technology innovations or best practices.

EVALUATION (return to coordinator at conclusion of workshop)

Petroleum Technology Transfer Council Appalachian Region Workshop

"Value-Added CCS: CO_2 EOR and CO_2 ECBM"
February 12, 2008

1. How did you hear about the workshop?

6	Direct mailing	**1**	Periodical	**0**	Phone
9	E-mail	**1**	Internet/www	**5**	Other

2. What additional topics would you like to see in future Focused Technology Workshops? **See other page**

3. Are you a(n):
   - **4** Operator (field supervisor, geologist, engineer)
   - **1** Service Company employee
   - **5** Consultant
   - **6** Educational Institution employee
   - **6** State/Federal Government employee

4. Please circle the response that best indicates your agreement, with 5 being the strongest:

	5	4	3	2	1
A) The program met my expectations	**4**	**13**	**4**	**0**	**0**
B) The speakers/facilities were acceptable	**8**	**11**	**1**	**1**	**0**
C) The program was well organized	**8**	**9**	**2**	**1**	**0**

5. The workshop fee was: **1** too low **20** OK **0** too high

6. Additional comments: (Please use back of page if needed).
   See other page

7. Please indicate which tech transfer method is most helpful to you. Rank from 1 to 5, with 5 being the most helpful:

	5	4	3	2	1	
Workshop (89 pts)	**13**	**3**	**2**	**2**	**2**	(65% of first choices)
Individual assistance (54 pts)	**4**	**4**	**3**	**4**	**1**	(20% of first choices)
Reports/Case studies (48 pts)	**1**	**6**	**4**	**2**	**3**	(5% of first choices) (30% of 2nd choices)

Internet	5	4	3	2	1	(5% of first choices)
(45 pts)	**1**	**5**	**3**	**4**	**3**	(25% of 2nd choices)
Newsletters	5	4	3	2	1	(5% of first choices)
(38 pts)	**1**	**2**	**4**	**4**	**5**	(25% of 5th choices)

8. Have you attended other PTTC events? **13** Yes (how many? **1-50**) **8** No

Have you used any new technologies based on knowledge gained through PTTC events? **6** Yes **14** No If yes, please describe (in general) the application/results. (PTTC will only use your response with your permission.)
See other page

9. Would you be willing to share with others any technology innovations or best practices?
4 Yes **12** No If yes, briefly list topics/information you are willing to share. **See other page**

#2. What additional topics would you like to see in future Focused Technology Workshops?

More on Marcellus Shale.
Best practices for producing water from CBM wells.
Other EOR? Applicable for Appalachian Basin
Velocity modeling.
Synthetics
Advanced geophysical log interpretation
Fracture detection (eastern)
Remote sensing (eastern)

#6. Additional Comments:
The case study slides were good.
Written explanations of slides would be good to include.
Heat the room!
Good value fee.
Very nice facility
Good presentation - a lot of info in one day, but the notes provided are a good reference.
The temperature in the rooms needs regulated.
Very informational and educational.
Speaker was knowledgeable but difficult to listen to for 8 hours,
Need to break up delivery to keep us awake.
Many numeric references were listed/presented greater than 2 years old. Module on ECBM was weak and needs to be revised, researched and better packaged.

I was hoping to see more emphasis and discussion on screening CO2 flood candidates (fields and reservoirs).. E.g. what reservoir types and drive mechanisms are optimal to be Co2 flooded?

Organization issue with this course. The ECBM part seemed out of context of the EOR part. By putting ECBM part in middle of EOR discussion, it interrupted flow of ideas. Discussion of "huff &puff" CO2 injection seemed to lose focus.

Would have been nice if some of the WV pilot (5-Pilots) tests were summarized.

#8. Have you used any new technologies based on knowledge gained through PTTC events?

Fracture identification
Use of petra mapping techniques.
CBM Geology.
Shale Geology.
Considering fractures in my research.
Commercial application of the new tech with varying results.
In my CO2 sequestration research - planning regional exploration research.

#9. Topics/info willing to share.

Once I have obtained some research results in this area.
CO2 sequestation.

2/12/2008	Value-Added CSS: CO2 EOR and CO2 ECBM	Morgantown	WV	WVU	
LastName	**FirstName**	**Address**	**City**	**State**	**PostalCode**
Avary	Katharine Lee	1 Mont Chateau Rd	Morgantown	WV	26508
Bajura	Richard	P.O. Box 6064	Morgantown	WV	26506
Beebe	Luke	215 Fifth St.	Marietta	OH	45750
Breitmeier	John	600 Dart Rd	Mason	MI	48854
Buffington	Tiffany	445 W. Main Street	Clarksburg	WV	26301
Burruss	Robert	National Center MS 956, 12201 Sunrise Valley Dr.	Reston	VA	20192
Carpenter	Steve	6860 Skies Edge Ct. #42	Cincinnati	OH	45247
Carter	Kris	400 Waterfront Dr.	Pittsburgh	PA	15222
Chase	Bob	215 Fifth Street	Marietta	OH	45750
Cramer	John W.	PO Box 550	Hartville	OH	44632
Dawley	Joseph	600 Quarrier St.	Charleston	WV	25301
Dedrickson	Clifton	Bldg 740, Office 3416, PO Box 18410, 3200/3300 Kanawha Turnpike	South Charleston	WV	25303
Freeman	Dave	215 Fifth Street	Marietta	OH	45750
Hairfield	Craig	Ste. 203 11277 Airpark Rd.	Ashland	VA	23005
Huang	Haixiao	P.O. Box 6108	Morgantown	WV	26506
Hunnefeld	Matt	215 Fifth St	Marietta	OH	45750
Kostelnik	Jaime	400 Waterfront Dr.	Pittsburgh	PA	15222
Lewis	Eric	1 Mont Chateau Rd	Morgantown	WV	26508
Liu	Guoxiang	779 Chestnut Ridge Road, Apt. 101	Morgantown	WV	26505
McClure	Jeff	109 Grove Ave.	Clarksburg	WV	26301
McKoy	Mark L.	3610 Collins Ferry Rd.	Morgantown	WV	25601
Medina	Cristian R.	611 N. Walnut Grove	Bloomington	IN	47405-2208
Melzer	Steve	P.O. Box 2083	Midland	TX	79702
Organek	Larry E.	P.O. Box 30256	Lansing	MI	48909
Peterson	Dorothy	102 Apple Street, Ste. 102	Tinton Falls	NJ	7724
Ramsey	Heather N.	900 Pennsylvania Ave	Charleston	WV	25302
Road	William E	625 Washington Rd. Ste 404	Pittsburgh	PA	15228
Roblee	Kyle	One Alpha Place, P.O. Box 2345	Abingdon	VA	24212
Rodvelt	Gary	184 Summers St., Ste. 200	Charleston	WV	25301
Scandrol	Roy	400 Brownsville Rd	South Park	PA	15129
Smith	Valerie	Brooks Hall	Morgantown	WV	26506

Su	Hui	P.O. Box 6108	Morgantown	WV	26506
Sun	Qingyun	P.O. Box 6108	Morgantown	WV	26506
Taylor	Al	11429 Purple Beech Drive	Reston	VA	20191
Urian	Brett	PO Box 444	Canal Fulton	OH	44614
Watts	Royal	15 Fairway Lane	Fairmont	WV	26554
Wilcox	Clay	900 Pennsylvania Ave	Charleston	WV	25302
Wilson	Tom	231 Brooks Hall	Morgantown	WV	26506
Wright	Brent	215 Fifth St.	Marietta	OH	45750