CO$_2$-Enhanced Oil Recovery, Applying a Mature Technology in Kentucky

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GOEP Supported Sequestration-EOR Projects

- Sequestration and CO$_2$-Enhanced Oil Recovery (EOR) in Ky. (H.B. #1 Sub-Project)
- Geochemical Analysis of Surface and Shallow Gas Flux and Composition..., cost share $69.5K, July 1, 2005-June 30, 2006
Sequestration—CO$_2$ EOR Goals

- **H.B. #1**—“quantify the potential for enhanced oil and gas recovery...using carbon dioxide.”

- Facilitate and participate in pilot projects that test suitability of representative reservoirs and field conditions for sequestration/CO$_2$ EOR.

- Identify and trouble-shoot geologic, engineering, and economic challenges.

- Develop “best practices” criteria to be used in future CO$_2$-EOR projects.

- Evaluate carbon storage potential.
National Context of CO$_2$-EOR*

- First large-scale projects developed early 1970’s in Permian basin, TX and NM.
- Permian basin dominantly miscible pattern flooding- recovered 7-25% additional of original-oil-in-place (OOIP).
- 2005- west Texas used ~1.4 BCFD of “new” CO$_2$ ($10-20/ton) to produce 180,000 BOPD.
- Elsewhere, ~72 active projects in OK, WY, CO, MI, MS, NM, and Saskatchewan.

*National information from Melzer (2007).
Big Andy EOR

- CO$_2$ trucked from TN
- $87$/ton to wellhead
- Truck = 20 tons (344,828 ft$^3$)
- Field deployed N$_2$ membrane
- Economics being evaluated

*Big Andy information courtesy of Bernie Miller.
*Photos courtesy of B. Nuttall.
Kentucky’s EOR Potential

- Ky. original-oil-in-place ~2.4 billion barrels (Nuttall, 2005 unpublished data)
- Remaining oil ~ 1.7 billion barrels; implies ~29% recovery efficiency
- Additional recovery @ 7% = 119 million barrels
Kentucky’s Potential Cont’d

CO₂ used: 1 to 7 million metric tonnes per year

Dᵢ=5.4%  
Dᵢ=7.6%  
B=0.31

Incremental production from CO₂ EOR: 60 to 200 million barrels

Modeling from Nuttall, unpublished.
CO$_2$-EOR Mechanisms

- Miscibility, or lack thereof, between injected CO$_2$ and oil is main factor influencing how oil is recovered.
- Miscibility is controlled by temperature, pressure, and oil composition.
- Miscible CO$_2$-EOR is most effective (additional recovery: avg. = 12%, range = 7-25%).
- Condensing/vaporizing mechanism between CO$_2$ and oil produces low viscosity single hydrocarbon phase in reservoir.
CO$_2$-EOR Mechanisms Cont’d

• Immiscible CO$_2$-EOR is less effective (additional recovery = 6-7%), and occurs where reservoir pressure is low or oil is heavy.

• Recovery occurs primarily by:
  – Oil swelling
  – Reduced viscosity
  – Extraction of lighter hydrocarbons
  – Reservoir pressurization

• ~86% of Ky. Fields have P-T and oil conditions that will produce immiscibility!!
Euterpe Pilot, Henderson Co.

- Discovered 1928; major development in 1950’s and 1960’s
- ~1.1 MMBO oil produced

Map from Takacs et al. (2007)
Euterpe Pilot, Henderson Co.

• KGS & ISGS $300K each
• Industry partner—Basin Petroleum
• Immiscible pattern flood
• Inject ~1800 tonnes CO$_2$ 08-10/2008

Map from Takacs et al. (2007)
Weyburn Field- Example of EOR and Carbon Storage*

- Williston basin oil field (Saskatchewan) discovered in 1954
- CO₂ flood begun in 1996 with CO₂ from synfuels plant in North Dakota
- To date, >110 BCF CO₂ injected and 6 MMBO produced
- Looking forward, 22 million tons CO₂ to be stored and 130 MMBO produced over 20 year life of project

Evaluation of Geologic Sequestration Potential and CO₂-EOR in Kentucky

- Task 1.0—Broader EOR Potential to include:
  - Inventory of prospective oil fields
  - Characterize oil field brine chemistry

- Task 2.0—Broader CO₂ Sequestration Potential
  - Sequestration potential maps
  - Cross-sections along major river corridors
  - Evaluation matrix to score sequestration potential
  - Base map showing distribution of seismic data

- Task 3.0—Sequestration Potential of Coal-to-Liquids Site
  - Geologic evaluation w/ compilation of reservoirs, seals, and data availability