The CO$_2$ Enhanced Oil Recovery Story

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Outline

1. CO₂ Enhanced Oil Recovery Overview
   – Oil Field Development Sequence
   – US: Current and Future
2. A Deeper Look
   – How it works
   – How its done
3. Safety and Environmental
   – Our Track Record
A Representative Oil Field Development Sequence

- **Primary**
- **Secondary**
- **CO2 EOR**

10-20% OOIP
15-25% OOIP
10-15% OOIP
Over the past 30+ years, the oil and gas industry has:

- Produced and injected more than 10.8 TCF of CO2 from 7 sources.
  - 1.2 TCF of which came from sources that otherwise would have been vented.
- Constructed over 3100 miles of CO2 mainline pipeline systems.
- Produced in excess of 1.2 billion barrels of incremental oil.
- Secured operating practices of:
  - Corrosion management, Metallurgies, Elastomers
  - Separation, Dehydration and Hydrocarbon extraction
  - Compression/pumping
  - Injection and production well completion and operation

Sources: Oil & Gas Journal, Personal Knowledge
U.S. CO2 EOR Business

Currently injecting 2.5 BCF/d

Rockies potential demand: 0-1.7 BCF/D

Illinois potential demand: 0-0.4 BCF/D

Potential U.S. EOR CO₂ Consumption:

13.5 Bcf/d
or
0.26 GT CO₂/yr

Domestic EOR could reduce U.S. emissions by 4%

Source: ARI/DOE Feb 2006
CO2 EOR Expected to be ~25% of US Oil Production by 2030

Source: AEO 2008
CO₂ is produced from 8,500' wells in SW Colorado.

High Pressure & High Purity CO₂ is dried and further compressed until in supercritical phase (“liquid”).

CO₂ is then pumped to 2200 lbs pressure into a 30” pipeline system.

CO₂ is metered into the oil field.

CO₂ and the entrained oil from producer wells in the oil field.

CO₂ is re-injected into the oil bearing formation ~ 3500’ – 9000’ below the surface.

Oil is separated and the CO₂ is returned to the injection wells.

CLOSED SYSTEM.
CO₂ Enhanced Oil Recovery: Process Schematic

- CO₂ mixes with oil much like turpentine cleans paint from a brush
- Inter-phase mass transfer typically yields NGL rich gas production
- CO₂ produced with the oil is captured, dehydrated, and reinjected - a closed system
- Chase water injection helps control mobility and gas recycle
CO$_2$ Enhanced Oil Recovery: Animation
A Representative* Permian Basin CO2 EOR Project

Volumetric Summary
Original Oil In Place: 600 MMB
67 MMB EOR 11% 400 BCF purchased
Net CO2 Utilization 6 Gross CO2 Utilization 15.8

Economic Summary
Capex: 8% of oil price per bbl
CO2 Cost: 2.5% of oil price per MCF
Payout: 5 years
IRR: 20%

*Not necessarily typical
Environmental, Health, and Safety:

Myths:

CO2 is toxic

• It's in the air we breathe and does not explode

• The operating risks include corrosion, high pressure, and asphyxiation – all of which have been successfully controlled by the industry for nearly 40 years

CO2 EOR results in significant releases to the environment

• Our EOR operations emitted 0.3% of the total volume of CO2 we handled in 2008
  • Key causes for releases: Routine maintenance and power outages caused by storms

• Our source operations emitted .004% of the volume we produced in 2008
  • Key cause for releases: Routine maintenance

• Our reportable emissions on our 1300 miles of pipe in 2008 was .000035% (equivalent to emissions from 2 vehicles during the same time frame)
CO$_2$ Enhanced Oil Recovery - Recap

It has reduced oil imports, and could generate ~25% of domestic production in 2 decades

- Uses existing footprint versus green-field developments

The environmental and safety track record in source, pipeline and EOR operations is commendable

- CO$_2$ releases to the atmosphere represent a tiny percent of the total volume involved

The operating practices to drill and complete wells, install needed piping, and construct required gas processing facilities has been successfully deployed by the industry for nearly 40 years

- The technologies developed since the ‘70’s have paved the way for CCS