U.S. CO2 EOR Projects: How many? ~95 (~53 in Permian Basin)

- Currently, 100 Domestic CO2-EOR projects provide 250,000 B/D
- Affordable natural CO2 launched CO2-EOR activity in the 1980’s
- Federal tax credits (Sec.43) and state severance tax relief still encourage CO2-EOR
USA – Permian Basin CO₂ Floods

**Number of Active Operated CO₂ Projects**

- **West Texas CO₂ Floods**
- **First floods initiated 35 years ago**
- **Over 50 CO₂ floods in Permian Basin**

11 other companies
Occidental’s US Permian Basin Operations

- Largest Oil Producer in the State of Texas
- ~ 290,000 boe/d (gross)
  - ~70% oil, 15% NGL, 15% Gas
- 3,400,000 bw/d
- 1.5+ billion cf/d CO$_2$
- ~25,000 Wells
- ~1,100 Facilities
- 6 Major Gas Plants
- Bravo CO$_2$ Source
- ~5,000 Employees and Contractors
Permian Basin CO₂ EOR Production

![Bar Chart]

- **Oxy Properties**

<table>
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<th>Year</th>
<th>EOR Production (MBOPD)</th>
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<td>2008</td>
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What is CO₂ Enhanced Oil Recovery?

• Uses carbon dioxide as a solvent to improve oil recovery
• Viscosity of oil trapped in the reservoir is reduced providing ability for more efficient displacement
• Injected CO₂ produced with the oil is captured & recycled
• Some CO₂ is retained in the reservoir
• Industry has produced, transported & injected CO₂ without notable incident for over 35 years
• Many similarities & experience applicable to Carbon Capture & Storage (CCS)
What is the CO$_2$ Flood Process?
How Much Oil Does Injecting CO₂ Recover?
Permian San Andres Formation

Typical Oil Recovery

Remaining - 40%
Primary - 15%
Waterflood - 30%
CO₂ Flood - 15%

Oxy Denver Unit, Wasson Field

~2 Billion Barrel Oil OIP

CO₂ Flood (19.5% OOIP)
Waterflood (30.1% OOIP)
Primary (17.2% OOIP)
Oxy Denver Unit, Texas CO$_2$ EOR Results

Begin CO$_2$ injection; departure from waterflood decline

~30,000 bopd

~700 bopd
Oxy Cogdell Canyon Reef Unit, Texas CO₂ EOR Results

~7,500 bopd

Begin CO₂ injection; departure from waterflood decline

~250 bopd
What are N America EOR CO2 Sources?

North America Source Volumes

- Naturally Occurring Underground: 79%
- Total Volumes: ~2.2 bcfpd
- Total Volumes: 11.1%

Natural Gas Plants: 12.1%
Ammonia (Fert): 1.9%
Coal Synfuels: 7.2%
Ethylene: 0.1%
Ethanol: 0%
Refinery: 0%

Total Volumes: ~2.2 bcfpd

13th Annual CO2 Conference: Trinity CO2 - 4Q2007
Where are the CO2 Sources?

CO₂ Source Fields & Transportation System

- Colorado
  - Sheep Mtn.
- Kansas
  - McElmo Dome
  - Bravo Dome
- Oklahoma
- New Mexico
  - Southern Fields
How is Oxy’s CO2 Sourced?

- Oxy typically injects ~1.5 - 2.0 Bcfpd of CO₂ in the basin

- Recycle volumes processed from oil/gas production
Putting it all together: Field Flow Diagram

- **Gas Sale**
- **Gas Compr.**
- **CO₂ Rec. Plant**
- **Prod. Well**
- **Test Facility**
- **Tank Battery**
- **CO₂ Pipeline**
- **CO₂ Make-Up**
- **Inj. Well**
- **Water Inj. Stat.**

**Processes:**
- Oil, Wtr, Gas/CO₂
- Gas/CO₂
- CO₂ Recycle
- CO₂ Make-Up
- Water
Different CO2 Flood Designs Require Different CO2 Plants

North Hobbs Unit Reinjection Facility
(Full Stream Reinjection)

Denver Unit CO₂ Recovery Plant
(H₂S Removal & NGL Recovery)
Is CO2 EOR Applicable Everywhere?

- Requires sufficient oil target (if profit required)
- Requires CO2 source
- Requires specific geological characteristics
  - Adequate flood sweep efficiency (formation homogeneity, stratified or low vertical permeability, few fractures)
  - Adequate processing rate (CO2 velocity: permeability and porosity)
  - Low minimum miscibility pressure (low reservoir temperature, low reservoir pressure)
CO$_2$ EOR Summary

- Increases oil recovery 15-25%
- The process is a closed loop system since CO$_2$ produced with the oil is recovered & recycled
- CO$_2$ is treated as an expensive, scarce commodity; similar to farmer’s seed money
- Proven technology: Industry has 35+ yrs of experience
- CO$_2$ will generate >1 billion barrels of incremental oil in Oxy operated fields
CO2 EOR relationship to Carbon Capture & Storage (CCS)

1. CCS has 4 steps: waste capture, compression, pipeline transportation, & injection; (oil industry has been doing 3 of these steps for 35 years)

2. Oil industry has an excellent CO₂ track record

3. Oil industry is proving ground/laboratory for CO₂ sequestration

4. Oil industry is a practical part of the solution
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Within the city limits Wassen Field, Denver City, TX: 30+ yrs injecting CO2