Reduction of Greenhouse Gas Emissions through Underground CO_2 Sequestration in Texas Oil and Gas Reservoirs

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Final Report

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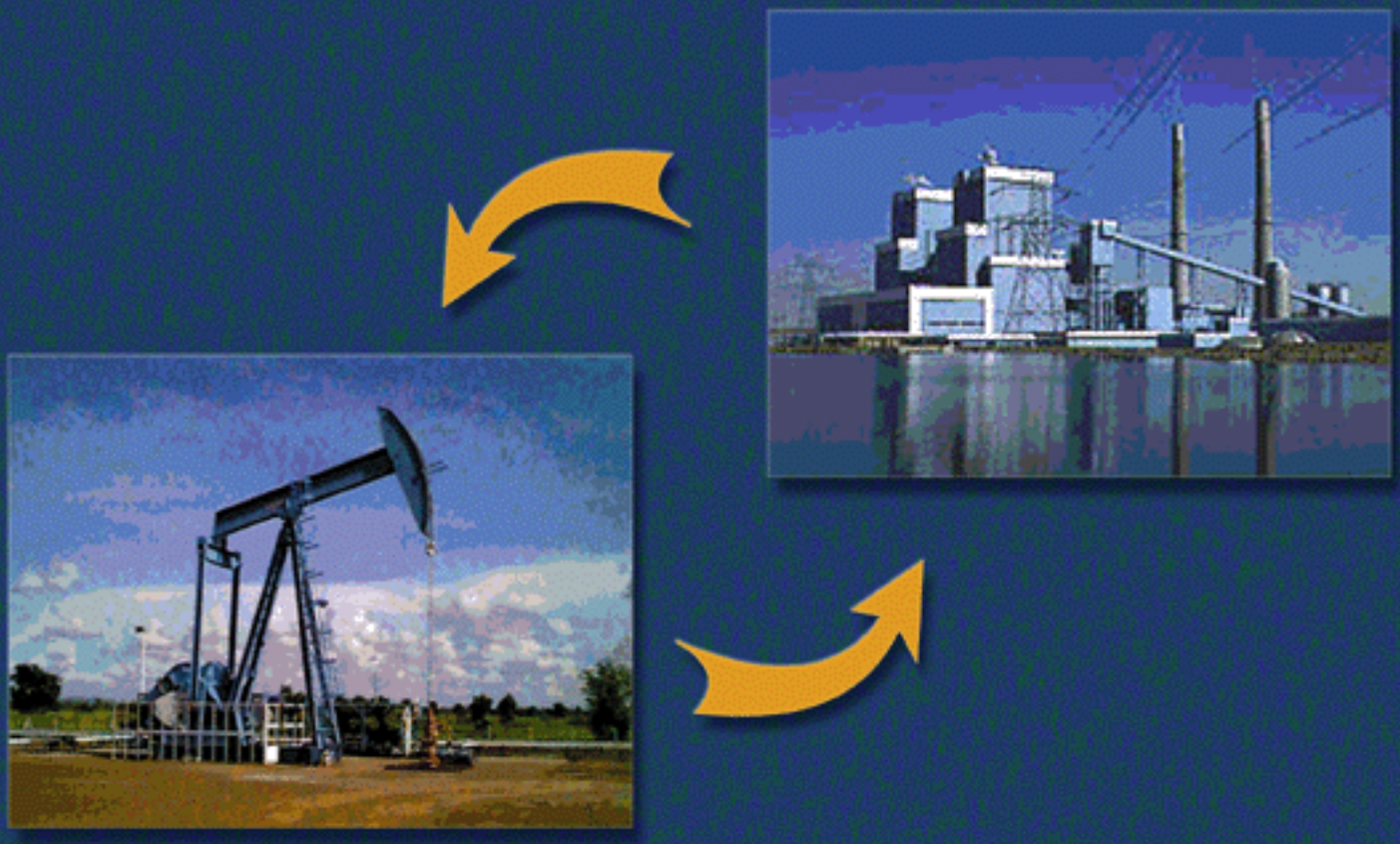

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Abstract

Today, energy and environmental questions are often viewed from conflicting perspectives. However, perhaps there are solutions to some of these problems that can satisfy multiple objectives. This report explores the technical feasibility and economic potential for capturing CO_2 from coal- or lignite-fired utility boilers and applying the CO_2 as an enhanced oil recovery (EOR) process in the mature oil provinces of Texas. This capture accomplishes twin goals—sequestering a substantial amount of CO_2 for an extended period and increasing the efficiency of oil recovery.

The types of CO_2 sources are diverse. To mitigate the impact of these, a number of management strategies are available, ranging from effluent reduction to capture and sequestration. One alternative is to utilize mature oil reservoirs to form a set of sequestration reservoirs. From the oil production side, one challenge for the domestic oil industry during the next millennium will be to profitably employ advanced technology to increase resources from existing reservoirs. Many advanced recovery strategies hold potential for accomplishing this goal. One promising area is enhanced oil recovery through the use of CO_2 flooding. The potential incremental oil production from these methods is significant.

The electricity generation industry is currently a major source of atmospheric CO_2 emissions. One industry challenge in the coming decades may be to profitably employ advanced technology that reduces CO_2 output while maintaining generation availability and reliability. There are likely to be many different strategies applied to new generation additions. However, the numbers of viable alternatives for existing facilities are relatively limited. CO_2 capture and sequestration in mature oil reservoirs appear to be one important management alternative for the existing generating unit.

Original oil in place in existing, discovered Texas reservoirs is estimated at 197 billion stock-tank barrels (BSTB), of which 147 BSTB of oil remains in place. Reserves total 7 BSTB, leaving 140 BSTB of remaining mobile and residual oil. This 140 BSTB is the target for additional reservoir development including CO_2 EOR.

Previous research has indicated that a primary target for EOR is estimated at 74 BSTB of residual oil. This study finds that 8 BSTB of this resource is within a 90-mi (145-km) radius of the candidate coal- or lignite-fired plants in Texas.

Additional oil resources beyond this 8 BSTB are also available from oil fields located near natural-gas-fired facilities. However, additional CO_2 effluent management issues need to be addressed with these facilities. Factors influencing the recovery of these resources include CO_2 production cost and availability, generation unit characteristics, transportation cost, environmental regulations, and oil prices.

Modeling conducted in this study indicates that CO_2 flooding can produce oil that would not otherwise be recovered, at an incremental cost between $6.00 and $16.00 per stock-tank barrel (STB). The upper end of this range exceeds current (December 1998) posted crude oil prices

($/STB). In addition, it is likely that between 12 and 20 years of CO_2 production from the candidate lignite- or coal-fired boilers can be sequestered from these generation facilities.

Preliminary analyses indicate that CO_2 capture for lignite- and coal-fired plants in Texas may be cost-effective when compared with fuel-switching these same boilers to natural gas. From a policy standpoint, it may be desirable to encourage CO_2 capture retrofit initially, as opposed to fuel switching, because this results in overall lower levels of CO_2 emissions at a comparable cost.

We conclude that there is substantial potential for using utility plant boiler effluent as a CO_2 supply source for flooding and using mature oil reservoirs for CO_2 sequestration. Development of this potential resource base may be facilitated through further research and policy initiatives. Major unresolved issues remain, however, that include:

- Total CO_2 sequestration potential in Texas and U.S. hydrocarbon reservoirs.
- Consideration of projected generation capacity additions expected during the next several decades.
- Development of a longitudinally consistent supply-and-demand balance.
- Development of an integrated CO_2 supply network that minimizes pipeline costs and considers CO_2 storage costs to determine if CO_2 can be made available on a large scale.
- An engineering and performance audit of the existing CO_2 floods in Texas to better determine oil recovery efficiencies that can be expected by depositional system type.
- An engineering and performance evaluation of potential CO_2 sequestration management issues that might allow for overpressuring reservoirs (compared with initial pressure).
- An engineering and economic examination of CO_2 capture and transportation and for flue gas capture and transportation (as a potential lower cost alternative to CO_2 capture) for natural-gas-fired plants.
- An engineering and economic examination of potential CO_2 sequestration management issues that might be associated with variable output plants (peaking facilities and intermediate load plants). For effective enhanced oil recovery processes, dedicated CO_2 storage facilities that can release CO_2 to other underground reservoirs following the EOR process needs may be suggested.
- Alternatively, partial load (and conceivably full load) operation of generation facilities may suggest that unprocessed effluent be stored with CO_2 separation conducted during off-peak periods when prices of power are relatively low. During on-peak periods when prices of power are relatively high, CO_2 separation may be deferred through storage of CO_2-rich (but "unrefined") effluent.
- Further analysis of the costs of compression, transportation, and the capacity constraints that these developments may project onto the existing electrical grid.
- Additional work on developing potential applications for CO_2 usage to ensure long-term sequestration is needed. Topics of concern include metallurgy and corrosion issues, reservoir seal integrity, and impacts on subterranean ecosystems.

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Introduction—Factors Affecting CO_2 Sequestration

Objectives of Study

This study addresses the feasibility of reducing CO_2 power plant emissions in Texas by using the emissions for CO_2 enhanced oil recovery. To test this feasibility an understanding of the current state of CO_2 supply and costs is undertaken. The literature is extensively reviewed and evaluated to determine the key engineering and geologic characteristics influencing CO_2 sequestration. Another objective was to evaluate the characteristics of previous and current gas-displacement recovery projects, Texas oil and gas reservoirs, and Texas power plants. These characteristics were then used to determine candidate reservoirs that have the potential and the feasibility to use power plant CO_2 emissions for enhanced oil recovery.

Current CO_2 Supply

West Texas CO_2 Supply

To understand how CO_2 from power plants may be used for enhanced oil recovery an understanding is needed as to how current supplies are being managed. In the early1970s, Permian Basin oil reservoirs were maturing to the point that producers became interested in pursuing tertiary recovery methods to enhance oil recovery. Large quantities of CO_2-saturated natural gas were produced nearby, and large quantities of CO_2 were being extracted from natural gas and vented into the atmosphere. A Chevron affiliate conceived and developed the first CO_2 flood in the area (Sacroc), and Canyon Reef Carriers ("CRC") constructed a 220-mi (354-km) CO_2 pipeline from four CO_2 extraction plants (Shell–Terrell, Valero–Grey Ranch, Northern–Mitchell, and Warren–Puckett) to the field to be flooded (Sacroc).

With the success of Chevron's flood, high oil prices, and many old oil fields to be flooded, the demand for CO_2 was so high that major oil companies built three long-haul (500-, 403-, and 210-mi [804-, 648-, and 338-km]) CO_2 pipelines into the Permian Basin in the early to mid-1980s sustaining a large volume of input into the Permian Basin area (fig. 1). Distribution pipelines were built in the area, including the 143-mi (230-km) Central Basin Pipe Line (CBPL), which extends from Denver City, Texas (where the three long-haul pipelines converged), to the Yates Field. Most of these pipelines were built on the strength of long-term CO_2 purchase contracts.

Currently three major pipelines are supplying West Texas with carbon dioxide from natural sources (fig. 2). Two pipelines transport CO_2 from the McElmo Dome. The 502-mi (808-km), 30-in. (76-cm) Cortez Pipeline carries CO_2 to the Denver City Hub in West Texas, and the smaller 40-mi, 8-in. McElmo Creek Pipeline supplies Mobil's McElmo Creek Unit in Utah. Cortez has a capacity of 1 billion standard cubic feet per day (Bscf/d) to 4 Bscf/d, currently delivering up to 1.1 Bscf/d of 98% pure CO_2. McElmo Creek can carry approximately 60 million cubic feet per day (MMcf/d). The McElmo Dome is one of the largest known CO_2 supplies in the United States, containing more than 10 trillion cubic feet (Tscf) of CO_2. Primarily owned by Shell (the operator) and Mobil, the McElmo Dome produces from the Leadville Formation at 8000 ft (2438 m) with 44 wells that produce at individual rates up to 100 MMcf/d. Ironically, while one industry has spent substantial capital producing CO_2, another industry has a disposal problem.