QUARTERLY TECHNICAL PROGRESS REPORT
FOR THE PERIOD ENDING DECEMBER 31, 2002

TITLE: FIELD DEMONSTRATION OF CARBON DIOXIDE MISCIBLE FLOODING IN THE LANSING-KANSAS CITY FORMATION, CENTRAL KANSAS

DOE Contract No. DE-AC26-00BC15124

Contractor: University of Kansas Center for Research, Inc.
2385 Irving Hill Road
Lawrence, KS 66044

DOE Program: Class II Revisited - Field Demonstrations

Award Date: March 8, 2000

Total Project Budget: $5,388,683

DOE Cost Amount: $1,892,094

Program Period: March 8, 2000 – March 7, 2009 (BP1 03/00-05/03, BP2 05/03-03/08, BP3 03/08-03/09)

Reporting Period: October 1, 2002 – December 31, 2002

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DISCLAIMER:

ABSTRACT:

Progress is reported for the period from October 1, 2002 to December 31, 2002. On September 27, 2002 the US DOE approved the proposed modified plan to flood a 10+-acre pattern. On November 1, 2002 Murfin Drilling Company purchased the 70-acre pilot area and will continue as the operator of the pilot. Murfin is seeking working interest partners and meetings with local small independents were conducted. To date, White Eagle Resources and John O. Farmer Oil Company have committed to working interest in the project. Arrangements have been made with Rein Operating to test the Rein #7 water supply well on the neighboring lease. Based on review of wellbore conditions in the Colliver #9 and #16 it has been decided to use the #16 in the pilot. A new tank battery was installed near the Colliver #10 well and the existing producers plumbed to the new tank battery to isolate production from the pilot area. Reservoir simulations have indicated that the low-permeability interval in the Carter-Colliver CO2I#1 injection well below 2,900 ft does not exhibit sufficient injectivity to warrant special stimulation or conformance treatment programs at the present time. Discussions have been initiated with FLOCO2 and preliminary conditions have been agreed upon for the exchange of CO2 for the use of storage and pump equipment at the pilot. A short-term injection test and the well reworks have been scheduled. Proposed modifications to the project plan were reviewed in the previous quarterly technical progress report. A presentation was given at the DOE Class II Review Meeting in Midland, TX on December 12, 2002.

TABLE OF CONTENTS

TITLE PAGE 1
DISCLAIMER 2
ABSTRACT 2
TABLE OF CONTENTS 3
LIST OF TABLES 3
LIST OF FIGURES 3
INTRODUCTION 5
EXECUTIVE SUMMARY 5
RESULTS AND DISCUSSION 5
  TASK 2.3 Remediate and Test Wells and Pattern 5
  TASK 3.1 Reservoir Simulation (Phase 2) 7
  TASK 3.2 Economic and Recovery Analysis of Pilot 7
  TASK 7.0 PROJECT MANAGEMENT 8
  TASK 8.0 TECHNOLOGY TRANSFER 8
CONCLUSIONS 10

LIST OF FIGURES

Figure 1. 10+-acre Pilot Pattern 6
Figure 2. Permeability in the L-KC C zone in the Carter-Colliver CO2I#1.....7

INTRODUCTION

Objectives - The objective of this Class II Revisited project is to demonstrate the viability of carbon dioxide miscible flooding in the Lansing-Kansas City formation on the Central Kansas Uplift and to obtain data concerning reservoir properties, flood performance, and operating costs and methods to aid operators in future floods. The project addresses the producibility problem that these Class II shallow-shelf carbonate reservoirs have been depleted by effective waterflooding leaving significant trapped oil reserves. The objective is to be addressed by performing a CO_2 miscible flood in a 10-acre (4.05 ha) pilot in a representative oomoldic limestone reservoir in the Hall-Gurney Field, Russell County, Kansas. At the demonstration site, the Kansas team will characterize the reservoir geologic and engineering properties, model the flood using reservoir simulation, design and construct facilities and remediate existing wells, implement the planned flood, and monitor the flood process. The results of this project will be disseminated through various technology transfer activities.

Project Task Overview -

Activities in Budget Period 1 (03/00-05/03) involve reservoir characterization, modeling, and assessment:

- Task 1.1- Acquisition and consolidation of data into a web-based accessible database
- Task 1.2 - Geologic, petrophysical, and engineering reservoir characterization at the proposed demonstration site to understand the reservoir system
- Task 1.3 - Develop descriptive and numerical models of the reservoir
- Task 1.4 - Multiphase numerical flow simulation of oil recovery and prediction of the optimum location for a new injector well based on the numerical reservoir model
- Task 2.1 - Drilling, sponge coring, logging and testing a new CO2 injection well to obtain better reservoir data
- Task 2.2 - Measurement of residual oil and advanced rock properties for improved reservoir characterization and to address decisions concerning the resource base
- Task 2.3 – Remediate and test wells and patterns, re-pressure pilot area by water injection and evaluate interwell properties, perform initial CO2 injection to test for premature breakthrough
- Task 3.1 - Advanced flow simulation based on the data provided by the improved characterization
- Task 3.2 - Assessment of the condition of existing wellbores, and evaluation of the economics of carbon dioxide flooding based on the improved reservoir characterization, advanced flow simulation, and engineering analyses
- Task 4.1 – Review of Budget Period 1 activities and assessment of flood implementation

Activities in Budget Period 2 (05/03-03/08) involve implementation and monitoring of the flood:

- Task 5.4 - Implement CO_2 flood operations
- Task 5.5 - Analyze CO_2 flooding progress - carbon dioxide injection will be terminated at the end of Budget Period 2 and the project will be converted to continuous water injection.

Activities in Budget Period 3 (03/08-03/09) will involve post-CO2 flood monitoring:

- Task 6.1 – Collection and analysis of post-CO2 production and injection data

Activities that occur over all budget periods include:

- Task 7.0 – Management of geologic, engineering, and operations activities
- Task 8.0 – Technology transfer and fulfillment of reporting requirements

EXECUTIVE SUMMARY:

Progress is reported for the period from October 1, 2002 to December 31, 2002. On September 27, 2002 the US DOE approved the proposed modified plan to flood a 10+-acre pattern. On November 1, 2002 Murfin Drilling Company purchased the 70-acre pilot area and will continue as the operator of the pilot. Murfin is seeking working interest partners and meetings with local small independents were conducted. To date, White Eagle Resources and John O. Farmer Oil Company have committed to working interest in the project. Arrangements have been made with Rein Operating to test the Rein #7 water supply well on the neighboring lease. Based on review of wellbore conditions in the Colliver #9 and #16 it has been decided to use the #16 in the pilot. A new tank battery was installed near the Colliver #10 well and the existing producers plumbed to the new tank battery to isolate production from the pilot area. Reservoir simulations have indicated that the low-permeability interval in the Carter-Colliver CO2I#1 injection well below 2,900 ft does not exhibit sufficient injectivity to warrant special stimulation or conformance treatment programs at the present time. Discussions have been initiated with FLOCO2 and preliminary conditions have been agreed upon for the exchange of CO2 for the use of storage and pump equipment at the pilot. A short-term injection test and the well reworks have been scheduled. A presentation was given at the DOE Class II Review Meeting in Midland, TX on December 12, 2002.

RESULTS AND DISCUSSION:

TASK 2.3. Remediate and Test Wells and Pattern

2.3.1 Drill, Complete, and Equip Water Supply Well - Arrangement were made with Rein Operating to pump test the Rein #7 water supply well for water chemistry and supply rates. Rein Operating has agreed to provide the well for water supply to the project. This well produces low-salinity water (~4,900 mg/l total dissolved solids). The well is presently shut-in and a pump and tank will be moved on location for testing. Murfin is reviewing costs and applying for a water supply well permit to provide for the possibility that it is more efficient to drill a new well near the project tank battery. Water supply well drilling contractors have been contacted to obtain scheduling information. Tests have been scheduled for sampling water from the Rein #7, Carter-Colliver CO2I#1, Colliver #18 injection water, and Russell City water to test for fines and compatability between reservoir brine (C-C CO2I#1) and possible injection waters. Following compatability testing a temporary tank and pump will be set up to perform a three- to seven-day injectivity test on the CO2I#1 using suitable injection water. Filtration equipment design and costs are being investigated.

2.3.2 Workover and Test Producing Wells in Pilot Area -The choice of using #9 or #16 for the northeast producer was to be based on the wellbore conditions. Review of the plugging record and measurements of the top of cement in the #9 indicate that the well is plugged to the near-surface. Records for #16 indicate a 7-inch, 20 lbs/ft, casing to 2,222 ft with open hole from 2,222 to 2,252 ft and fill from 2,248 to 2,252 ft. Slotted liner from 2,218 to 2,248 ft should be able to be pulled. Considering the age (1940) and weight (13.8 lbs/ft) of casing in the #9 and the volume of cement to be drilled it has been decided to pull the liner in #16 and drill the #16 deeper to the Lansing-Kansas City C zone. This will provide a clean wellbore, new logs, the possibility of

obtaining another core, and should be able to be performed at less risk and potentially at less cost. It will also slightly increase the pattern size. The 10+-acre flood pattern with the #16 as a producer is shown in Figure 1.

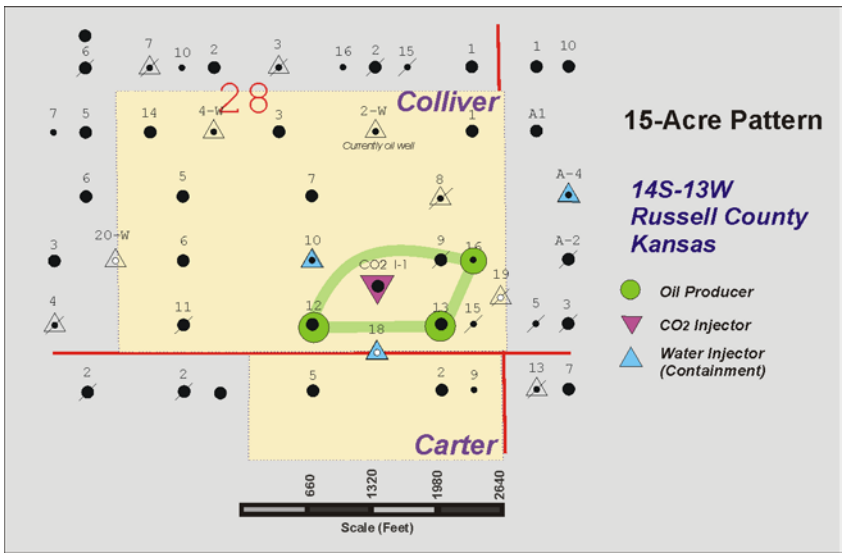

Figure 1. Planned 10+ acre pilot with WAG injection in CO2#1, water injection in #10 and #18, and production from #16, #12, and #13.

2.3.3 Workover Containment Water Injection Wells in Pilot Area -Analysis of reservoir simulations with and without water injection in the Colliver #10 indicate that injection in #10 is necessary for pressure support and containment. Review of the critical nature of this well resulted in a change in the well rework schedule presented in the original step-wise implementation plan presented in the last Quarterly Report. It was decided that following the short-term injectivity test, well reworks would be performed in the following sequence: Colliver #12, Colliver #10, Colliver #16, Colliver #13.

2.3.4 Injection Well Testing and Analysis – Analysis of the June, 2000 acid stimulation job performed on Colliver #18 indicated that this treatment provided information on the mechanical properties of the Lansing-Kansas City in the pilot area. Based on injection pressures and injection rates of 720-1,400 barrels per day, the data can be interpreted to indicate the following properties: Breakdown Pressure > 2,200 psi, Fracture propagation pressure ~ 2,114 psi, and closure pressure ~ 1,965 psi. Based on these pressures, and the current lower reservoir pressure around the CO2I#1 due to production, the short-term injection test is designed to not exceed 50 psi at the surface or 1,300 psi bottom hole pressure. This represents a short-term injection pressure that is approximately 600 psi greater than the reservoir pressure. Test duration is from three to seven days.

2.3.5 Construct Surface Facilities -A new tank battery was installed near the Colliver #10 well and the existing producers plumbed to the new tank battery to isolate production from the pilot area.

TASK 3.1. Reservoir Simulation (Phase 2)

Injection well CO2I-1 is perforated in the interval from 2891-2899 ft. The interval between 2899 and 2906 ft is currently behind pipe. Simulations have investigated the relative role of the lower permeability interval below 2,900 ft, which exhibits permeabilities below 3 millidarcies (Figure 2). This interval may or may not be isolated from the overlying reservoir by a very low-permeability barrier. Simulations indicate that stimulation of this lower interval when there is no vertical permeability barrier can increase the average water injection rate in CO2 #1 by up to approximately 50%. However, injected fluids move vertically up into the overlying higher permeability rocks and there is little displacement in the low-permeability interval beyond the immediate vicinity of the injection well. If a barrier exists between the low- and overlying high-permeability intervals, the injectivity into the lower interval is too low to provide a significant region in which pressures exceed the minimum miscibility pressure. Based on these results, a special stimulation program or implementation of a conformance control program to limit injection in the upper interval to enhance injection in the lower interval is not being considered at the present time.

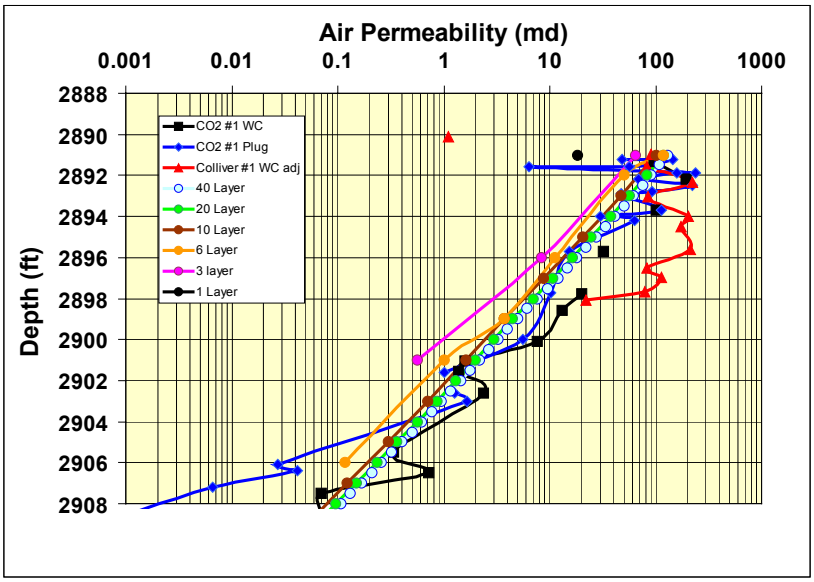

Figure 2. Permeability distribution in the Lansing-Kansas City C zone in the Carter-Colliver CO2I#1 well showing the lower permeability interval below 2,900 feet. Simulations indicate this interval does not represent a sufficiently productive target to warrant special stimulation programs.

TASK 3.2 Economic and Recovery Analysis of Pilot

3.2.1 Determine CO2 Source for Pilot – Discussions have been conducted with Kinder-Morgan CO2 Company (K-M) concerning how their CO2 contribution will be implemented. It is presently estimated that the pilot will use approximately 270 million standard cubic feet over a four- to five- year period. Injection will begin with a CO2 slug that will be followed by a water-alternating-gas (WAG) injection program. K-M plans to provide CO2 on an as-used basis with either monthly or quarterly accounting periods.

Negotiations have been re-initiated with FLOCO2. FLOCO2 has verbally agreed that, provided contract terms can be agreed upon, they will accept K-M CO2 and will provide the Pilot a CO2 storage tank and pump in exchange for received CO2. Terms for the contract, including the CO2 delivery schedule, are being discussed.
U.S. Energy Partners is ready to provide liquid CO2 from the Russell ethanol plant when needed.

Specifications for how EPCO liquid CO2 trucks will hook up to and transfer CO2 to the on-site storage tank need to be agreed upon to avoid possible back-flow of CO2 from storage tank to transport truck.

3.2.3 Design Facilities for Pilot and Monitoring – Pilot surface facilities design have been reviewed. Specifications for CO2 transfer and injection have been reviewed.

TASK 7.0 PROJECT MANAGEMENT

On September 27, 2002 the US DOE approved the proposed modified plan to flood a 10+-acre pattern. Contracts were signed in mid-October.

On November 1, 2002 Murfin Drilling Company (Murfin), a partner in MV Energy LLC, bought the 70-acre southeast corner of the Colliver lease, containing the demonstration site, from MV Energy LLC. Murfin will continue as the operator for the demonstration. While continuing with the demonstration, Murfin is seeking working interest partners. Material was sent out to independents operating in the area. To date, White Eagle Resources and John O. Farmer Oil Company have committed to working interest in the project.

A meeting was held in Russell, KS, November 26, 2002, to present information about the project to prospective partners. Representatives from Murfin Drilling Company, John O. Farmer Oil Company, Rein Operating, Bennett & Schulte, and GLM Company were in attendance.

A technical meeting was held at the Murfin Drilling Company filed office on November 26, 2002, the following personnel were present: Murfin Drilling) James Daniels; Stan Froetschner, Kevin Axelson ;Tertiary Oil Recovery Project) Paul Willhite, Richard Pancake; Kansas Geological Survey) Alan Byrnes, Martin Dubois; Kinder-Morgan) William Flanders (by phone), Don Schnacke. Topics covered included: 1) Water Supply, 2) Colliver #9/#16 questions, 3) Rework scheduling and preparation, 4) CO2 storage and injection facilities, 5) Project management.

TASK 8.0 TECHNOLOGY TRANSFER

Alan Byrnes presented a review of the project at the DOE Shallow Shelf Carbonate Class II Review Meeting in Midland, Texas December 12, 2002. The powerpoint talk is presented on the CO2 website and will be available from proceedings published by the DOE. The abstract for the talk is presented below.

"FIELD DEMONSTRATION OF CARBON DIOXIDE MISCIBLE FLOODING IN THE LANSING-KANSAS CITY FORMATION, CENTRAL KANSAS
Class Revisited DE-AC26-00BC15124; Alan P. Byrnes (Project Manager Budget Period 1, G. Paul Willhite (Project Manager Budget Periods 2 & 3)

The objective of this Class II Revisited project is to demonstrate the viability of carbon dioxide miscible flooding in the Lansing-Kansas City (L-KC) formation on the Central Kansas Uplift and to obtain data concerning reservoir properties, flood performance, and operating costs and methods to aid operators in future floods. In Kansas, the L-KC has produced 1.2 billion BO primarily from oomoldic grainstones in 3,500 fields. Primary production for in the Hall-Gurney Field, the largest L-KC oil field in Kansas and where the pilot is located, began in the 1930's, and was

followed by extensive waterflooding in the late 50's and early 60's. Many L-KC waterfloods reached their economic limits in the 70's and 80's but by-passed oil represents a significant resource for CO2 miscible flooding.

The pilot pattern has undergone changes reflecting better understanding of reservoir properties, and changes in CO2 supply, and partnership roles. The present pattern comprises half of a 20-acre inverted 5-spot with one central injector, three producers, and two water injection containment wells. Detailed reservoir characterization of the 12-18 foot CO2 target zone at the demonstration site indicates the presence of up to three stacked, shallowing-upward cycles contained within a single higher-order shallowing-upward sequence accompanied by vertically increasing porosity (4-30%) and permeability (0.04-200 md). Approximately 270 million cubic feet of CO_2 will be trucked seven miles from an ethanol plant in Russell, stored in an above-ground tank, compressed, and injected into the single injector in a super-critical state. The site is being pressured to above 1250 psi (Minimum Miscibility Pressure for L-KC oil) by water injection. Following repressurization, an initial CO2 slug will be followed by Water-Alternating-Gas (WAG) injection to decrease conformance problems. Reservoir performance has been modeled using both a 6- and 13-layer compositional model using the Landmark *VIP* numerical simulator and analogues to West Texas floods. Production from the 10+acre three-producer pattern is projected to be over 26,000 barrels of oil, over a four-year period.

The CO2 miscible flood demonstration project represents the first use of CO2 for enhanced oil recovery in Kansas and is the first to use CO2 emissions from ethanol production in an EOR project. With electrical co-generation, ethanol fuel production and CO2 enhanced oil recovery, the project represents a model for linked energy systems. A successful demonstration could lead to development of both linked-energy systems and construction of a CO2 pipeline into central Kansas with potential for application of this technology to other Class II reservoir systems across the Central Kansas Uplift, potentially impacting production practices for the next two decades and leading to estimated additional recovery of hundreds of millions of barrels of oil. Partners in the project include the U.S. Department of Energy, Murfin Drilling Company, John O. Farmer Inc., White Eagle Resources Corp., Kinder-Morgan CO2 Company, US Energy Partners LP, the University of Kansas (Kansas Geological Survey and Tertiary Oil Recovery Project) and the Kansas Department of Commerce & Housing. The $5.4 million project is funded under the Class Revisited Program Contract # DE-AC26-00BC15124, DOE Project Manager is Paul West. Details of the project can be obtained at www.kgs.ukans.edu/CO2/index.html."

A press release was issued by the University of Kansas Office of University Relations on December 19, 2002:

"Contact: Alan Byrnes, Kansas Geological Survey, (785) 864-2177.

Tests to begin on Russell County oil field to see if carbon dioxide process possible

Photos of the testing location are available via e-mail. Contact 864-2106 or rex@kgs.ku.edu.

LAWRENCE -- Tests are scheduled to begin early next year to determine if an oil field southeast of Russell, in central Kansas, is a good place to try using carbon dioxide to strip more petroleum from underground.

If carbon dioxide can be used, it could dramatically change the way oil is produced in much of the state.

Scientists at the Kansas Geological Survey and Tertiary Oil Recovery Project, both at the University of Kansas, are working with local oil companies and several industry and governmental partners to begin the tests, probably in January.

Carbon dioxide has been used to force additional oil from fields in other parts of the country, but not in Kansas. For the past two years, KU researchers have been studying subsurface rock samples and computer models from the Russell County field to see if it is suitable for testing the use of carbon dioxide in Kansas.

"We're ready to move from the computer to the field," said Survey petroleum geologist Martin Dubois.

The tests focus on a 10-acre patch in the Hall-Gurney field, about 6 miles southeast of Russell. The field, which has produced more than 150 million barrels of oil since its discovery in 1931, produced about 500,000 barrels in 2001. Production has dropped by almost half during the past decade.

The researchers plan to inject water through an existing well into one of the oil-producing rock formations about 3,000 feet underground. That test should show whether the water can repressure the depleted field, which is a first step toward renewed production. If that test is successful, the researchers plan to inject liquid carbon dioxide into a portion of the field within the next six months. That carbon dioxide will come from a recently constructed ethanol plant in Russell.

"Injecting water into the field is a first step in testing the oil reservoir to make sure that it is appropriate for the use of carbon dioxide," said Paul Willhite, co-director of KU's Tertiary Oil Recovery Project. When carbon dioxide is

injected into rock formations, it acts as a solvent, stripping some of the remaining oil that was otherwise trapped underground. Then both the oil and some of the carbon dioxide are pumped to the surface.
"For the carbon dioxide test to be economically successful at this location, it will have to help produce an additional 20,000 to 30,000 barrels of oil over the next four years," said Alan Byrnes, a petroleum geologist at the Survey.
If the carbon dioxide forces out enough oil, the technique may have widespread application in Kansas. Byrnes estimates that carbon dioxide might generate millions of additional barrels of Kansas crude.
"If you can prove that this works in central Kansas, it could work in lots of other areas around the state," Dubois said.
Though the Russell ethanol plant could supply enough carbon dioxide for much of the Hall-Gurney field, producers would need larger sources of carbon dioxide for more widespread application. Most likely they would look to "geologic" sources of carbon dioxide, places where carbon dioxide occurs naturally underground, particularly in New Mexico and Colorado. Such fields are operated by Kinder Morgan CO2 Company, a partner in the Russell project. That carbon dioxide could be transported to Kansas via pipeline.
In the meantime, however, industrial sources should generate sufficient carbon dioxide for tests and small carbon dioxide flooding projects. If the Hall-Gurney project is successful it might open up a market for carbon dioxide from the Russell plant and future ethanol plants in Kansas. And it could provide a way to reduce the amount of carbon dioxide that would otherwise be released into the atmosphere. Because of the possible role of carbon dioxide in global climate change, such underground disposal is considered environmental preferable.
The Russell location is particularly attractive because the local ethanol plant, the Hall-Gurney field and Russell's recently completed electrical generation plant are so close together. Waste heat from the new power plant is transferred to the nearby ethanol plant where it is used to ferment grain, which is purchased locally. That fermentation produces ethanol, which is used as an additive in fuels. The fermentation also produces carbon dioxide that can be used for a variety of purposes, such as dry ice. Some of the Russell carbon dioxide is shipped to Salina and used in a plant that makes frozen pizzas.
If water-injection tests at the oil field are positive, carbon dioxide will be trucked from the ethanol plant to the oil field. Researchers plan to pump about one truckload of carbon dioxide per day into the subsurface for about six months, then alternate injections of carbon dioxide and water for the next four years. About half of the carbon dioxide will come back to the surface with the oil that is produced; the other half will remain underground.
"Everybody involved is eager to get some carbon dioxide into the ground," said Jim Daniels of Murfin Drilling Company Inc., the company that operates the field and is one of the partners in the project. "This could have a very significant economic impact on the region."
KU's research on the use of carbon dioxide to produce oil from the Hall-Gurney field is being funded in part by the U.S. Department of Energy and the Kansas Department of Commerce and Housing. Other partners in the project include Murfin Drilling Co. Inc., Wichita; John O. Farmer Inc., Russell; White Eagle Resources Corp., Louisville, Colo.; Kinder-Morgan CO2 Co., Houston; and U.S. Energy Partners LP, Russell.
"We're excited about the potential of carbon dioxide to reinvigorate oil fields in the state," said Eric Mork of ICM Inc., located in Colwich and part-owner of U.S. Energy Partners. "It'll take a few years to see if this is viable, but it could give a great boost to oil producers and Kansas communities."
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CONCLUSIONS

Business matters concerning approval of the 10+ acre pilot and Murfin purchase of the pilot site have been concluded and implementation of the demonstration plan is proceeding. Basic surface facilities have been installed and facilities for water supply are being arranged. Based on the foundation work begun in this quarter the next quarter will involve major activities including several well reworks, short-term testing, long-term testing and repressurization.