The Russell Kansas CO2 Pilot – An Operator’s Perspective

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Mid-Year KIOGA
Russell, Kansas
April 21, 2005
Overview

- Short Background
- DOE Participation and Costs to Date
- Current Operations
- General Comments
Location of Ethanol Plant & CO2 Pilot Site

Kansas Geological Survey
Type Log CO2#18

L-KC “C” divided into 6 Layers-three flooding cycles

- General Properties*
  - C1: 8 md, 18.8%
  - C2: 150 md, 25.8%
  - C3: 40 md, 22.0%
  - C4: 6 md, 19.4%
  - C5: 2 md, 14.7%
  - C6: 0.3 md, 12.0%

* CO2#18 exhibits better properties than average for site
Russell CO2 Pilot
Cumulative Production and Injection

CO2 injection commenced December 1, 2003
Phase One – **DOE Contribution 45%**

- March 2000 to January 2004
- Perform Reservoir Characterization and Simulation
- Conduct Field Studies to Determine if CO2 Pilot Implementation Feasible (Included Well Workovers and Water Injection Facilities)
- Develop Working Interest Partnerships and Other Working Agreements (CO2 Supply, CO2 Transport, and CO2 Injection)
- Pre-startup Activities (Tank Battery Upgrade and CO2 Injection Equipment Set-up)
- Trial CO2 Injection
**DOE Participation**

- **Phase Two – DOE Contribution 35%**
  - February 2004 to December 2008
  - Implement, Operate, and Monitor CO2 Pilot

- **Phase Three – DOE Contribution 10%**
  - January 2009 to March 2010
  - Post CO2 Flood Monitoring (Water Injection)
  - Continue Tech Transfer Activities
**Costs to Date**

**Workover CO2 #18 to isolate LKC C**
- May & June 2000
- Cement squeeze several zones, reperf LKC C
- Total Cost = $58,000

**Drill and Complete CO2 I-1 into LKC C**
- September & October 2000
- Total Cost = $284,000
**Costs to Date**

**Run liner in CO2 #12 to isolate LKC C**
- February & March 2003
- Plug back LKC G w/ cement
- Cmt 4-1/2” liner in 6”, left LKC C openhole
- Total Cost = $50,000

**Workover CO2 #10 to isolate LKC C**
- March 2003
- Cement LKC C & G openhole
- Redrill LKC C and perforate
- Run tandem packer across shallow zones
- Total Cost = $93,000
Costs to Date

Drill Deeper CO2 #16 into LKC C

- March & April 2003
- Remove existing shallow liner (Jan ’03)
- Drill deeper into LKC C & G, cmt 4-1/2” csg to surface, perforate LKC C, acidize
- Total Cost = $122,000

Running KGS VSP Cable into 16

Fishing KGS VSP Cable from 16
Costs to Date

Construct Freshwater Injection Plant

- April 2003
- Drill freshwater supply well
- Lay lines, construct shed, set pump & tanks
- Total Cost = $71,000

Injection Pump & Filters

Laying Line to CO2 #10
Running Liner in CO2 #13

Perforating CO2 #13

Acidizing CO2 #13

Costs to Date

Run liner in CO2 #13 to isolate LKC C

- May 2003
- Cmt 4-1/2” liner (to surface in 6”) across LKC C & G
- Perforate & acidize LKC C
- Total Cost = $50,000

Perforating CO2 #13

Acidizing CO2 #13
Costs to Date

Set-up CO2 Skid and Upgrade TB

- November 2003
- Set-up CO2 injection skid & storage tank
- Install gas separator, FWKO, and water disposal tank at tank battery
- Total Cost = $11,000 (install CO2 skid only)
# Summary of Costs

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
</tr>
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<tbody>
<tr>
<td>Workover CO2 #18</td>
<td>$58 M</td>
</tr>
<tr>
<td>Drill &amp; Complete CO2 I-1</td>
<td>$284 M</td>
</tr>
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<tr>
<td>Construct Freshwater Plant</td>
<td>$71 M</td>
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<tr>
<td>Run Liner in CO2 #13</td>
<td>$50 M</td>
</tr>
<tr>
<td>Set-up CO2 Skid &amp; Tank</td>
<td>$11 M</td>
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<tr>
<td>Miscellaneous</td>
<td>$11 M</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>$750 M</strong></td>
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<table>
<thead>
<tr>
<th>Allocated to</th>
<th>Amount</th>
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<tbody>
<tr>
<td>Murfin &amp; WI Partners (55 %)</td>
<td>$412.5 M</td>
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<tr>
<td>DOE (45 %)</td>
<td>$337.5 M</td>
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</table>
Current Operations

Operational Issues

– CO2 Injection Pump too Big
  • Excessive CO2 recycle and venting
  • Pump requires overhaul July 2004; Smaller plungers inserted
  • Venting problem eliminated
Operational Issues

– Metering Inaccuracies
  • CO2 rate measurement at skid inaccurate
  • Pump pulsation creates backflow through turbine meter
  • CO2 rate, temperature, and pressure measurement relocated to CO2 I-1 June 2004

Current Operations
Operational Issues

- CO2 #12 Pumping Problems
  - CO2 gas production causes foam on backside
  - Difficult to obtain accurate fluid level – Is well pumped off?
  - Total production drops off – Is well gas locking?
  - Dynamometer card ran – Pump may be bad
  - New pump ran March 2005 – Production improves
  - Does issue with gas locking remain?

- CO2 #13 Not Connecting with CO2 Front
  - CO2 Huff-n-Puff done December 2004
  - Oil production improves for +/- 2 months then drops off
Current Operations

Operational Issues

– Water Management Issues
  • Attempt to maintain constant water injection in blocker wells
  • CO2 #18 +/- 20 bwpd
  • CO2 #10 +/- 350 bwpd

– Corrosion Problems
  • None Encountered to Date
Russell CO2 Pilot
Average CO2 I-1 Injection Rate and Pressure

Oct-03 Jan-04 Apr-04 Aug-04 Nov-04 Feb-05 May-05

CO2 I-1 Rate (mcfd) CO2 I-1 Surface Pressure (psig)
Russell CO2 Pilot
CO2 #12 Daily Production

CO2 injection begins December 1, 2003
CO2 production May ’04
Production drop Jan ’05
Pump change March 15, 2005

Graph showing CO2 injection and production data from October 2003 to May 2005.
Russell CO2 Pilot
CO2 #13 Daily Production

- CO2 injection begins December 1, 2003
- Huff-n-Puff December 9, 2004; 43 tons CO2. Well SI 26 days.
- CO2 production July ‘04

Graph showing daily production of Oil (bpd), Water (bpd), and Gas (mcfd) from Oct-03 to May-05.
Russell CO2 Pilot
Total Daily Production & Injection

Oct-03 Jan-04 Apr-04 Aug-04 Nov-04 Feb-05 May-05

Oil (bpd) Water (bpd) Gas (mcf/d) CO2 Injected (mcf/d)
Current Operations

Monthly Costs

– Lease Operating Expense (LOE)
  • Average $11,900/month without DOE cost-share
  • Average $ 8,900/month with DOE 35% cost-share

– Economic Limit at Current LOE (w/ DOE cost-share)
  • 8.4 bopd @ $40/bbl oil price
  • 7.4 bopd @ $45/bbl oil price

– Emphasize Cost-Sharing
General Comments

- Economics of scale/Use of existing infrastructure
- LKC heterogeneities
- Single zone project advantage
- Sequestration incentives?
- Truck hauling CO2

Will Project Continue?
Thanks!