Kansas CO2 Enhanced Oil Recovery
History and Potential

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Improved Hydrocarbon Recovery, LLC,
In collaboration with
Kansas Geological Survey
The Prize: 250 million barrels of oil

The Pathway:

- Formative years 1999 – 2017
  - Analysis and pilot projects
  - Initial point-to-point from ethanol plants
- Post 45Q or $80 oil price
Oil-rich state, but no appreciable CO2

6.6 Billion barrels

Now at 36 mmbo/yr

CO2 EOR +10 mmbo/yr possible??

Most prolific are LKC and Arbuckle
The Big Picture

From the Midwest Governor’s Association and ARI (2009)

• Kansas holds > **750 million barrels** of technical CO2-EOR potential.

• Kansas has the largest oil resources in the MGA region.

<table>
<thead>
<tr>
<th>Basin</th>
<th>EOR potential (Mil bbl)</th>
<th>Net CO2 Demand (MMT)</th>
<th>Direct Jobs Created</th>
</tr>
</thead>
<tbody>
<tr>
<td>Illinois/Indiana</td>
<td>500</td>
<td>160 – 250</td>
<td>1,550 – 3,100</td>
</tr>
<tr>
<td>Ohio</td>
<td>500</td>
<td>190 – 300</td>
<td>1,550 – 3,100</td>
</tr>
<tr>
<td>Michigan</td>
<td>250</td>
<td>80 – 130</td>
<td>800 – 1,800</td>
</tr>
<tr>
<td>Kansas</td>
<td><strong>750</strong></td>
<td>240 – 370</td>
<td>2,300 – 4,600</td>
</tr>
<tr>
<td>TOTALS</td>
<td>2,000</td>
<td>670 – 1,050</td>
<td>6,200 – 12,400</td>
</tr>
</tbody>
</table>

Byrnes et al., 1999 (Kansas Geological Survey)

250 to 1,000 million barrels
What’s required for 250 mmbo?

4.3 M tonne / yr CO2 (220 mmcf/d) for 25 yrs

Ethanol CO2 gathering scenario
✓ 4.3 Mt/yr from 15 plants
✓ To Kansas for EOR/storage

✓ 4.3 Mt/yr for EOR
✓ 8 mcf/BO net utilization
✓ 10 mmbo per year
(28% of current KS production)
✓ 250 mmbo in 25 years
CO2 EOR and CCUS Headlines (1997-present)

Kansas Ethanol Plants (2008)

Blue – active, Tan - planned

KGS and industry partners land $1.5M for Phase I in DOE CarbonSAFE program

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"CO2 Ready" EOR candidates

<table>
<thead>
<tr>
<th>CO2 EOR Ready Level</th>
<th>Inject. Rate (Mt/yr)</th>
<th>CO2 Stored (Mt)</th>
<th>Primary &amp; Secondary (mmbo)*</th>
<th>CO2 EOR (mmbo)</th>
<th>Basis for Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shuck</td>
<td>1</td>
<td>0.4</td>
<td>1.5</td>
<td>7.9</td>
<td>3.6</td>
</tr>
<tr>
<td>Cutter</td>
<td>1</td>
<td>0.5</td>
<td>1.3</td>
<td>5.4</td>
<td>2.8</td>
</tr>
<tr>
<td>N Eubank</td>
<td>1</td>
<td>0.6</td>
<td>1.5</td>
<td>7.4</td>
<td>4.6</td>
</tr>
<tr>
<td>Pleasant Prairie</td>
<td>1</td>
<td>0.3</td>
<td>0.5</td>
<td>4.7</td>
<td>2.2</td>
</tr>
<tr>
<td>Hall Gurney</td>
<td>1</td>
<td>1</td>
<td>11.3</td>
<td>62.5</td>
<td>26.8</td>
</tr>
<tr>
<td>Trapp</td>
<td>2</td>
<td>0.5</td>
<td>4.3</td>
<td>31.3</td>
<td>10.3</td>
</tr>
<tr>
<td>Wellington</td>
<td>1</td>
<td>0.6</td>
<td>2.2</td>
<td>16.2</td>
<td>5.3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>3.9</strong></td>
<td><strong>22.8</strong></td>
<td><strong>135.4</strong></td>
<td><strong>55.7</strong></td>
<td></td>
</tr>
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</table>

* P&S production is for portion of field that could be flooded

"CO2 Ready" fields could take 3.9 million tonnes /year (200 mmcf/da) And recover 56 mmbo
Murfin’s (and KGS) Hall-Gurney Pilot

Murfin’s Hall Gurney (Russell) Pilot (2005)
- Trucked CO2 from USEP Russell ethanol plant
- Injected 140 mmcf (7400 tonnes CO2)
- Produced an estimated 27.9 mbo incremental oil
- Gross Utilization: 5 mcf/BO

C12 Energy (2015)
- Projected 10.7 MBO recovery from proposed Unit
- KCC denied pooling application
Berexco’s (and KGS) Wellington Pilot (2016)
DOE-FE-006821

• Injected 374 mmcf CO2 (19,800 tonnes) over 165 days through June 2016
• Projected Incremental oil - 32.4 mbo
• Projected Gross utilization: 11.5 mcf/BO
Four fields in KGS/DOE study “CO2 Ready”

Could take **2 Mt/yr + 13.2 mmbo** from EOR

Seismic depth-converted Meramec surfaces **(by Hedke)**
Pleasant Prairie So.
Chester IVF

Fig. 6.14 Lithofacies model
Eubank North Unit
Chester IVF

- 1370 ft wide
- 140 ft deep
- 200 ft deep

CI: 20 ft
VE: 7.5X

CCUS in Kansas, Sept 21, 2017, Wichita, KS
Here’s the upside potential: Arbuckle

Gravity-stable process successful in Canadian reefs

Kansas Arbuckle?

Source: U.S. Department of Energy/National Energy Technology Laboratory
Geneseo-Edwards study

Kansas Ethanol, LLC (Lyons, KS) and CAP CO2, LLC, 2010

- 55 MGY plant 15 miles to Geneseo-Edwards oilfield
- Did not go forward
  1. Not funded in DOE Phase II
  2. Drop in oil prices
  3. Geologic risk

<table>
<thead>
<tr>
<th>Cumulative Oil (mmbo)</th>
<th>CO2 stored</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOE Project</td>
<td></td>
</tr>
<tr>
<td>Gross</td>
<td>Arborcle</td>
</tr>
<tr>
<td>30.2</td>
<td>26.3</td>
</tr>
<tr>
<td>Balance Geneseo-Edwards</td>
<td></td>
</tr>
<tr>
<td>Stoltenberg</td>
<td>59.2</td>
</tr>
<tr>
<td>Bloomer</td>
<td>55.1</td>
</tr>
<tr>
<td>Kraft-Prusa</td>
<td>55.8</td>
</tr>
<tr>
<td>Chase-Silica</td>
<td>137.8</td>
</tr>
<tr>
<td>618.7</td>
<td>497.1</td>
</tr>
</tbody>
</table>
Summary

- Kansas’ resource base supports large scale CO2 EOR
- **4.3 Mt/yr** for 25 yrs and **250 mmbo** (conservative) is a very big deal
- **$12.5 Billion** in oil at $50/BO

Discussion

- We need 5X the resource base identified today for a 25-yr project
- Question for you: Where is it?

Later today in open discussion

- Sometime, we (you) will need to work together (COOP model??) to justify pipeline and ethanol plant infrastructure.
- Can this happen?