Wyoming CO$_2$ Status and Developments

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Agenda

• Status
• Industry Stakeholders
• Developments
• Supply
• Project Summary
• State-wide Summary
• CO$_2$ Balance
**Current Situation**

**Contracted Quantities**  
~50 MMcfd to Denbury (Grieve).

~35 MMcfd

~35 MMcfd

340 MMcfd

~115 MMcfd

30 MMcfd

~40 MMcfd

Greencore Pipeline  
Under construction
Future Projects

Riley Ridge (130-600 MMcfd) + pipeline

Lost Cabin (50 MMcfd)

Linc Energy UCG and Glenrock area projects

Carbon Energy UCG

DKRW Advanced Fuels / Med Bow F&P (200 MMcfd)
Market Participants

Producers:


**ConocoPhillips** - Supplier, owner of Lost Cabin Gas Plant. Contracted to supply ~ 50 MMcf/d to Denbury.

**ExxonMobil** - Supplier, owner and operator of Shute Creek facility, providing ~ 340 MMcf/d CO₂ to various clients. Pipeline operator.

Market Players

Consumers:

**Anadarko Petroleum Corporation** - Operator of Salt Creek and Monell projects, taking ~ 155 MMcf/d from ExxonMobil. Distribution pipeline operator.

**Chevron** - Consumer, operator of Rangely field, taking ~ 35 MMcf/d from ExxonMobil. Distribution pipeline operator.

**Devon Energy** - Consumer, operator of Beaver Creek field, taking ~ 35 MMcf/d from ExxonMobil. Distribution pipeline operator.

**Elk Petroleum** - Consumer, JV partner in Grieve Field. In JV partnership with Denbury Resources.

**Merit Energy** - Consumer, operator of Lost Soldier/Wertz fields, taking ~ 30 MMcf/d from ExxonMobil. Distribution pipeline operator.
Market Players

**Integrated Business Models:**


Other Activities

- Ongoing research program investigating nature and extent of Residual Oil Zones (ROZ) in the Bighorn Basin. **EORI**
- Ongoing CO\textsubscript{2} EOR project tracking. **EORI**
- Regional Management Plans. **BLM**
- Wyoming CO\textsubscript{2} Pipeline Initiative. **WPA/EORI/Govs Office**
Supply

• Shute Creek*
  • 1981: Exxon drilled exploration wells
  • 1984: Shute Creek Construction
  • 1986: First Production
Currently, only active supplier of CO₂ in Wyoming.
Can supply up to 340 MMcfpd.
Supplies Rangely, Monell, Beaver Creek, Bairoil Complex and Salt Creek.

• Natural Gas Production
  • Lost Cabin, Riley Ridge

• In-situ and Surface Coal Gasification
  • Carbon Energy, Linc Energy, Medicine Bow Fuel and Power et al.,

• Natural Gas Power Systems?

* From Condon and Parker, 2011: Shute Creek Treating Facility Project Updates. 5th Annual Wyoming CO₂ Conference, July 13, 2011
Shute Creek

2011 Shute Creek CO₂ Sales (MMcf/d) by EOR Project

- Salt Creek: ~115 MMcf/d
- Bairoil: ~30 MMcf/d
- Beaver Creek: ~35 MMcf/d
- Rangely: ~35 MMcf/d
- Monell: ~40 MMcf/d

Data from WOGCC website
## CO₂ EOR Project Summary (Dec, 2011)

<table>
<thead>
<tr>
<th>Project</th>
<th>Field</th>
<th>Reservoir</th>
<th>Injection Start</th>
<th>Total CO₂ Purchased (MMscf)</th>
<th>Cum. Incr. Oil* (bbls)</th>
<th>RF* (% OOIP)</th>
<th>UR₅₉₄* (Mscf/bbl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bairoil</td>
<td>Lost Soldier/Wertz</td>
<td>Tensleep, Darwin/Madison, Flathead</td>
<td>1986</td>
<td>331,328,494</td>
<td>65,828,061</td>
<td>~8%</td>
<td>~5</td>
</tr>
<tr>
<td>Beaver Creek</td>
<td>Beaver Creek</td>
<td>Madison</td>
<td>2009</td>
<td>38,283,234</td>
<td>2,459,387</td>
<td>~2%</td>
<td>~15</td>
</tr>
<tr>
<td>Salt Creek</td>
<td>Salt Creek</td>
<td>Wall Creek 2</td>
<td>2004</td>
<td>269,784,126</td>
<td>10,699,231</td>
<td>~1%</td>
<td>~25</td>
</tr>
<tr>
<td>Monell</td>
<td>Patrick Draw (Monell Unit)</td>
<td>Mesaverde Almond</td>
<td>2004</td>
<td>65,917,029</td>
<td>7,481,084</td>
<td>~7%</td>
<td>~9</td>
</tr>
</tbody>
</table>

* Incremental recovery, utilization ratio and recovery factors are highly sensitive to analytical assumptions. We have been as conservative as possible and our assumptions may not match those used internally by operators.
Utilization Ratio*

\[
UR_{\text{net}} = \frac{CO_2 \text{ purchased}}{\text{Incremental oil}}
\]

\[
UR_{\text{gross}} = \frac{CO_2 \text{ purchased} + CO_2 \text{ recycled}}{\text{Incremental oil}}
\]

- A measure of economic efficiency.
- Dependent on flood design and maturity.
  - \textit{WAG vs GS, number of HCPVs injected}
- Compare Salt Creek with Beaver Creek
  - SC: phased, WAG, pattern flood, 1099 MMBO OOIP.
  - BC: WAG-GS hybrid, Single development phase, 109 MMBO OOIP

- A measure of technical efficiency.
- Dependent on flood design and sweep efficiency.

* Incremental recovery, utilization ratio and recovery factors are highly sensitive to analytical assumptions. We have been as conservative as possible and our assumptions may not match those used internally by operators.
Wyoming CO₂ EOR (@ Dec, 2011)

CO₂ Oil by Project

- Bairoil
- Salt Creek
- Monell
- Beaver Creek

Monthly Production (BOPM)

Date:
- Jan-81
- Jan-82
- Jan-83
- Jan-84
- Jan-85
- Jan-86
- Jan-87
- Jan-88
- Jan-89
- Jan-90
- Jan-91
- Jan-92
- Jan-93
- Jan-94
- Jan-95
- Jan-96
- Jan-97
- Jan-98
- Jan-99
- Jan-00
- Jan-01
- Jan-02
- Jan-03
- Jan-04
- Jan-05
- Jan-06
- Jan-07
- Jan-08
- Jan-09
- Jan-10
- Jan-11
CO₂ Oil by Field

Since 1986 CO₂ EOR has produced 86.5 million barrels of Oil
Wyoming CO2 Oil and State Tax Revenue per year

Tax Revenue

CO2 Oil
If we are capturing and injecting CO\textsubscript{2} that would have otherwise been emitted to the atmosphere......

but producing fossil fuels that produce CO\textsubscript{2} when burned...

What exactly is our contribution to atmospheric CO\textsubscript{2} concentration?

The following 3 slides are entirely tongue-in-cheek
What we think we do…

• $\text{CO}_2$ injected $\rightarrow$ $\text{CO}_2$ produced
What the public thinks we do…

• Who cares so long as we’re making money
CO$_2$ Balance

What *some* environmentalists think we do…

- It's all a conspiracy by Big-Oil
**CO₂ Balance**

But what do we actually do?

- Requires Life Cycle Assessment
- Analysis of CO₂ *Avoidance*
- **Compare:** Total system CO₂ emissions under current scenario (with CO₂ EOR) against Total system CO₂ emissions under alternate scenario (no CO₂ EOR)
- This can be highly complicated but with a few simple assumptions it becomes a lot easier.

**Assumptions:**

- *All CO₂ purchased for CO₂ EOR in Wyoming is injected.*
- *All CO₂ injected is stored.*
- *Other CO₂ sources in the lifecycle (e.g. due to transportation, electrical power) are insignificant compared to CO₂inj and CO₂prod and are ignored.*
- 1 bbl of oil is equivalent to ~8.3 Mcf of CO₂*
- CO₂ Emissions to date *(X)*
- CO₂ injected (CO₂inj) = CO₂ purchased for CO₂ EOR purposes.
- CO₂ produced (CO₂prod) = CO₂ emitted by processing the incremental oil produced by CO₂ EOR.

* [http://www.epa.gov/cleanenergy/energy-resources/refs.html](http://www.epa.gov/cleanenergy/energy-resources/refs.html)
CO₂ Balance

A) Current Scenario (with CO₂ EOR)
   = X + CO₂_{prod}

B) Alternate Scenario (no CO₂ EOR)
   = X + CO₂_{inj}

Compare A:B

CO₂_{prod}:CO₂_{inj}
CO₂ Balance

\[ \text{CO}_2^{\text{prod}} = 715,736,915 \text{ Mcf (40,899,252 tons)} \]
\[ \text{CO}_2^{\text{inj}} = 705,312,883 \text{ Mcf (40,303,593 tons)} \]

Total emission contribution \( \sim 600,000 \) tons.

Reduction in emissions \( \sim 98.5\% \) (compared to ‘conventional’ recovery of same volume of oil)

= Green Oil!!
Conclusions

• Development of CO\textsubscript{2} EOR projects in Wyoming continues.
• In 2011, CO\textsubscript{2} EOR produced 6.5 million barrels of oil (12% of total oil production)
• CO\textsubscript{2} EOR, Condensate production (and the increasing influence of stimulated horizontal drilling) has halted the decline of oil production in Wyoming and will likely lead to an increase in the short to medium term.
• CO\textsubscript{2} EOR has produced 86.5 million barrels of oil from Wyoming reservoirs.
• CO\textsubscript{2} EOR drastically reduces the amount of CO\textsubscript{2} emitted to the atmosphere from oil produced.
Questions?

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