Helping Pay For CO$_2$ Capture Projects Through Geological Sequestration of CO$_2$ Used for Enhanced Oil Recovery (EOR)

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Summit Power Group, LLC

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Summit Power Group & Summit Carbon Capture

- Founded twenty-five (25) years ago by Don Hodel (Chairman emeritus), Secretary of Energy & Interior for President Reagan, and Earl Gjelde (Chairman), COO for Hodel at Energy & Under Secretary of Interior
- Types of power projects that Summit develops for itself and others:
  - Renewables: wind projects, solar projects, etc.
  - State-of-the-art natural gas-fired power plants
  - Coal gasification projects with carbon capture – and CO₂ for EOR
  - Post-combustion capture for fuel-burning power plants – & for EOR
- Summit has long-standing relationships with vendors, engineers, contractors, etc. – including new relationships with Chinese engineering and power companies, Chinese banks, and Chinese firms
- Summit projects completed to date: Totaling $9 B (current US dollars) and over 9,500 MW
- Summit CO₂ for EOR projects in development: Will total at least an additional $7-8 B (US dollars) when completed
United States emitted 5,383 million metric tons of CO$_2$ in 2012$^1$

Power generation accounts for 2,023 million metric tons of CO$_2$

Coal provided 52% of US electricity in 2000, and 37% in 2014

President Obama and the US Environmental Protection Agency (EPA) have proposed to cut power plant CO$_2$ emissions by thirty percent (30%) from 2005 levels by 2030

Efficiency, renewables, and nuclear power alone cannot achieve emissions reductions of this scale on a worldwide basis

Carbon capture from coal and natural gas power plants will need to be implemented to decrease CO$_2$ emitted to the atmosphere

Currently, CO$_2$ for Enhanced Oil Recovery (EOR) is the only economic large-scale way to cut CO$_2$ emissions from hydrocarbon based power plants (algae growing won’t suffice)

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EOR can help pay the costs of CO$_2$ capture

**Power Plants:**
1 MWh hour of coal combustion power
→
1 ton of CO$_2$ emitted
or
1 ton of CO$_2$ captured

**Oil Fields:**
1 ton of CO$_2$ injected & re-injected until 100% is trapped underground
→
2-3 barrels of additional oil produced

Revenue for CO$_2$ capture
Use of CO₂ for Enhanced Oil Recovery (EOR)

CO₂ acts as a solvent – oil that is “stuck” to the rock is released.
Long Ago: Original Reservoir is Fully Charged with Oil

Surface

Cap Rock

Oil

Water
Tectonic Activity Tilts & Structures Reservoir

Slides in this series adapted, with thanks, from Steve Melzer of ARI, a top US expert in this field
Water Entering Through The Surface Floods the Reservoir Over Geologic Time
NATURE’S WATER FLOOD LEAVES BEHIND:

1. HIGH OIL SATURATION IN STRUCTURAL HIGH AREAS (THESE BECOME “MAIN PAY ZONES”)
2. SOME UNSWEPT OIL ACCUMULATIONS IN THE ROCK
3. RESIDUAL OIL MIXED WITH WATER (10-60% oil, average ≤ 40%)
4. HIGH WATER SATURATION AT BASE OF RESERVOIR
TYPICAL SEQUENCE OF OIL PRODUCTION IN MAIN PAY ZONE:

1. PRIMARY PRODUCTION: NATURAL RESERVOIR PRESSURE
2. THEN: WATER FLOODING (SECONDARY RECOVERY)
3. THEN: CO₂ FLOODING (TERTIARY RECOVERY or EOR)*

*The technique of alternating water and CO₂ injections is called “water alternating gas” (WAG), also known as “wagging”
Oil Saturation in the Residual Oil Zone (“ROZ”) is essentially identical to that in the Main Pay Zone *AFTER Water Flooding*. This makes the ROZ attractive for CO₂ Flooding, too.

Initial Oil Saturation 60%-85%  
After Water Flooding 10-60%  

Initial Oil Saturation 10%-60%  
(mostly less than 40%)  

MAIN PAY ZONE  
RESIDUAL OIL ZONE
Today – Major West Texas Oil Fields Have Been Water Flooded and
More than 100 Fields are Under CO₂ Flooding in the Main Pay Zones

CO₂ Flooding is Now Being Performed in the Residual Oil Zone
Steve Melzer’s Expert Analysis of CO₂ for EOR in a Texas Oilfield:
Production in Red Circle = Total Barrels of Oil from CO₂
Production of “T” = Barrels from Tertiary CO₂ Recovery in Main Pay Zone
“Q” = Barrels from “Quaternary” CO₂ Recovery in Residual Oil Zone
CO₂ for EOR Potential – The U.S. Example

• United States has at least 48 billion barrels of CO₂ EOR potential¹
• Currently, 250,000 barrels a day of oil is produced with CO₂ EOR – at $100 per barrel, this represents $9+ billion in annual gross revenue
• About 20 billion tons of CO₂ is needed to produce 48 billion bbls of oil – if used for EOR, all 20 billion tons would be permanently sequestered
• Only ~60 million tons of CO₂ is currently injected per year for EOR
• At current rates of CO₂ injection, the US has at least 320 more years before depletion of EOR reservoirs (some estimates are much higher)
• But almost all CO₂ currently used for EOR is from geologic reservoirs
• Geologic reservoirs are depleting; must be replaced by anthropogenic CO₂ – that is, CO₂ captured from power plants and industrial facilities
• “The single largest barrier to expanding CO₂ flooding is the lack of substantial volumes of reliable and affordable CO₂” ¹

¹ US Oil Production Potential From Accelerated Deployment of Carbon Capture and Storage, Advanced Resources International Inc., March 2010
Natural CO₂ supplies can’t meet industry demand

Existing natural CO₂ sources in Texas Gulf, Permian, and Wyoming have capacity of ≈ 3 Bcf/day. Industry and US Government projections call for tripling of demand. Extra supply must come mostly from captured CO₂ (i.e., CCS from industry and power plants). One (1) Bcf/day is ≈ 20 million tons a year. So Kinder Morgan’s chart shows annual demand going from 60 million tons per year to 200 million tons per year.
Summit’s Texas Clean Energy Project will turn Coal, Salty Water & Air into Near-Zero Carbon Power, Fertilizer, and Sequestered CO₂ for EOR

Low Sulfur Coal via Railroad

Brackish Water Purified via Reverse Osmosis

Air Separation Unit

Coal Gasification, Gas Cleanup, and Gas Separation

Coal

Syngas

Syngas

CO₂

CO₂

Ammonia / Urea Complex

CO₂ Delivered to Oil Fields via Pipeline

Main Outputs: High Hydrogen Syngas (~95% H₂ / 5% CO) & Pure CO₂

195 MW low carbon power to San Antonio — about 1/12th the CO₂ of conventional coal plant

710,000 tons/yr delivered to CHS Inc. — about ¼ the CO₂ of typical fertilizer plant

2.0 mm tons per year delivered of CO₂ to Oil Companies, 100% eventually sequestered

* Additional revenue from sales of sulfuric acid, argon gas, & minor products
What Makes the Texas Clean Energy Project (TCEP) Important?

**TCEP will be the first power project world wide to:**

- Use state of the art technology to gasify coal AND
- Transform the output into two separate gas streams of hydrogen and CO₂ AND
- Sequester more than 90% of the coal’s CO₂ permanently AND
- Use the CO₂ commercially in enhanced oil recovery AND
- Demonstrate that this works for both the end use markets of power (lowest carbon content of any hydrocarbon power plant) and chemicals AND
- Pair China & the U.S. in funding & building a full-scale CO₂ capture power plant
World’s largest gasification project: In Ningxia

China leads the world in coal gasification for chemical products. China can lead the world in CO₂ capture from coal gasification, too. Why not oil production from captured CO₂ (EOR)? And low-carbon electric power from coal gasification?
CO$_2$ Can Also Be Captured from Coal-Burning Plants, including via Retrofitting those Plants. Capturing CO$_2$ from Flue Gas (Exhaust) of a Combustion Plant is Called “Post-Combustion Capture” (PCC).
Some active post-combustion capture projects

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Location</th>
<th>Fuel</th>
<th>Equipment Provider*</th>
<th>Status</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boundary Dam</td>
<td>Canada</td>
<td>Coal</td>
<td></td>
<td>Under Construction will be operating Fall 2014</td>
<td>160 MW. 90% capture. CO2 used for EOR.</td>
</tr>
<tr>
<td>W.A. Parish</td>
<td>US (TX)</td>
<td>Coal</td>
<td></td>
<td>Financial closing announced July 2014</td>
<td>250 MW. 90% Capture. CO2 used for EOR</td>
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<tr>
<td>Peterhead</td>
<td>UK (Scotland)</td>
<td>Gas</td>
<td></td>
<td>FEED stage</td>
<td>One of two winners of UK CCUS competition. Expected to begin operations in 2018</td>
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*Other suppliers of proven PCC systems include Huaneng/CERI, Linde/BASF, Fluor, etc.
## Questions & Answers about CO₂ for EOR

<table>
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<tr>
<th>Question</th>
<th>Answer</th>
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<tbody>
<tr>
<td>Do power plants need to capture carbon?</td>
<td>Yes. Power sector is largest source of CO₂. In the U.S., new rules demand huge cut in CO₂ emissions. <strong>Reduced carbon emissions = high priority in U.S. and China.</strong></td>
</tr>
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<td>Can power plants capture carbon?</td>
<td>Yes. Huaneng /CERI has captured CO₂ in China. Systems being installed now in North America (Shell &amp; Mitsubishi).</td>
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<td>Can oil wells really use CO₂?</td>
<td>Yes. In the US, about 100 million barrels/year come from CO₂ use. China could produce as much or more. China has suitable geology in main pay zones and residual oil zones.</td>
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<td>Will oil producers pay for CO₂?</td>
<td>Yes. Current prices about $35-40 per ton in Texas. Lower in some states, potentially higher in other states.</td>
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<td>Can CO₂ be transported?</td>
<td>Yes. Already ≈ 5,000 miles of CO₂ pipelines in the U.S.</td>
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<td>Does CO₂ for EOR produce permanent carbon sequestration?</td>
<td>Yes. CO₂ that comes to the surface with oil is re-compressed and re-injected. Ultimately it all stays down.</td>
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<td>Doesn’t the produced oil have carbon, too?</td>
<td>Yes. But much less than the CO₂ that’s injected. No other oil production method traps CO₂ underground.</td>
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“Last year, the world used more wind power, solar energy, biomass, and hydro energy than ever before. We also used more coal, oil, natural gas, and nuclear power than ever before. We used more energy in total than ever before.”
Why CO$_2$ Sequestration Matters

Plaque on Mauna Loa in Hawai‘i

Carbon Dioxide (ppm)

Year

November 1997

300
325
350
375


Professor Charles David Keeling, Scripps Institution of Oceanography, who initiated continuous CO$_2$ measurements at this site in 1958

400 ppm

2014
Conclusion: CO$_2$ EOR is not new, it is important for sequestration – and it can help pay for CO$_2$ capture.
谢谢！ Thank you!

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