SLIDES: The Logistics and Energy Needs of Oil Shale Extraction

Alan K. Burnham

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The Logistics and Energy Needs of Oil Shale Extraction

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American Shale Oil, LLC

Presented at:
“The Promise and Peril of Oil Shale”
Denver, CO, February 5, 2010
There are a number of issues to be addressed for oil shale development:

- Water usage
- Contamination of aquifers
- Stress on communities:
  - Population growth
  - Infrastructure needs
- Land and wildlife disturbance
- Air pollution, including CO$_2$
Different processes have different impacts
(From Burnham & McConaghy, 2006 Oil Shale Symp.)

- There are many different oil shale processes with different characteristics

<table>
<thead>
<tr>
<th>Heating Method</th>
<th>Above Ground</th>
<th>Below Ground</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conduction through a wall (various fuels)</td>
<td>Pumperston, Fischer assay, Oil-Tech</td>
<td>Shell ICP (primary method), E.G.L.</td>
</tr>
<tr>
<td>Externally generated hot gas</td>
<td>Union B, Paraho Indirect, Superior Indirect, PetroSix</td>
<td>Chevron</td>
</tr>
<tr>
<td>Internal combustion</td>
<td>Union A, Paraho Direct, Superior Direct, Kiviter</td>
<td>Oxy MIS, LLNL RISE, Geokinetics Horizontal, Rio Blanco*</td>
</tr>
<tr>
<td>Hot recycled solids (inert or burned shale)</td>
<td>Galoter, Lurgi, Chevron STB, LLNL HRS, Shell Spher, ATP, TOSCO II</td>
<td></td>
</tr>
<tr>
<td>Reactive fluids</td>
<td>IGT Hytort (high-pressure H₂), Donor solvent processes</td>
<td>Shell ICP (some embodiments)</td>
</tr>
<tr>
<td>Volumetric heating</td>
<td></td>
<td>ITTRI and LLNL radio-frequency</td>
</tr>
</tbody>
</table>

- Different processes vary greatly in fuel source, CO₂ emissions, and energy gain

<table>
<thead>
<tr>
<th>Process</th>
<th>Oil Yield, %FA</th>
<th>Pyrolysis CO₂, kg/bbl</th>
<th>Combustion CO₂, kg/bbl</th>
<th>Carbonate CO₂, kg/bbl</th>
<th>Total CO₂, kg/bbl</th>
<th>Mitigation cost, $/bbl</th>
<th>Energy gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>HRS</td>
<td>100</td>
<td>11</td>
<td>77</td>
<td>40</td>
<td>128</td>
<td>3.8</td>
<td>~3</td>
</tr>
<tr>
<td>Internal comb</td>
<td>90</td>
<td>12</td>
<td>85</td>
<td>150</td>
<td>247</td>
<td>7.4</td>
<td>~8</td>
</tr>
<tr>
<td>MIS</td>
<td>80</td>
<td>14</td>
<td>96</td>
<td>352</td>
<td>462</td>
<td>13.9</td>
<td></td>
</tr>
<tr>
<td>Shell ICP¹</td>
<td>80</td>
<td>14</td>
<td>146</td>
<td>0</td>
<td>160</td>
<td>4.8</td>
<td></td>
</tr>
<tr>
<td>Shell ICP²</td>
<td>80</td>
<td>14</td>
<td>42</td>
<td>0</td>
<td>56</td>
<td>1.7</td>
<td></td>
</tr>
<tr>
<td>Chevron</td>
<td>80</td>
<td>14</td>
<td>96</td>
<td>120</td>
<td>230</td>
<td>6.9</td>
<td></td>
</tr>
</tbody>
</table>

¹using coal to generate electricity  ²using downhole methane burners  ³assume mitigation cost of $30/ton
The 160-acre BLM lease was established in January 2007 under EGL Resources and transferred shortly thereafter to EGL Oil Shale.

IDT acquired 90% of EGL Oil Shale in 2008 and renamed it AMSO.

In March 2009, Total acquired a 50% interest in AMSO.
In-situ processing is being pursued in Colorado’s Piceance Basin by others. ExxonMobil (Below Aquifers in the Saline zone) and Chevron (In Aquifers) are involved. All pictures taken from public presentations by these companies.
We propose to develop the illitic oil shale separated from aquifers by nahcolitic oil shale.
Our goal is to maximize benefits to the Nation and the local communities

- Our RD&D phase (~10 years) will involve about 20 people
- Our commercial process will use a small, stable labor force
  - Approximately 300 people for drilling and production operations
  - Production target of about 100,000 bbl/day*
- At 350 bbl/day per worker, each worker will produce enough oil for 5,000 people
- At a royalty rate of $10/barrel**, each worker would generate $1.2 million per year in royalties
  - It is important that part of these royalties are used to improve infrastructure in the area

* this exceeds Colorado’s average annual oil production of 57,000 bbl/day over the past decade
** The BLM has established a maximum royalty rate of 12.5%, which at a price per barrel of $80, would translate into $10/barrel
AMSO’s oil shale process effectively uses water for high economic contribution

- True in-situ processes have no mining, crushing, or spent-shale disposal needing water for dust control
- AMSO’s retort interval is isolated from drinking water, so no subsurface reclamation of water required
- Anticipated water usage is less than one barrel of water per barrel of shale oil
- Projected to 100,000 bbl/day, AMSO would use ~0.1% of the state’s water and generate ~1% of the state’s GDP

White River in Rio Blanco County
AMSO plans fewer wells to minimize surface footprint

- Our retort panels will achieve high resource recovery in the illite shale
- By using long horizontal wells, drilling should impact <10% of the surface area
Land reclamation has already been demonstrated from the 1980s activity.