Geothermal Energy and Waste Heat to Power: Utilizing Oil and Gas Plays

Energy Production with Mixed Hydrocarbons and Geopressed Integrated Hybrid Systems

March 13-14, 2013 Conference, SMU Campus, Dallas, TX
“Nonconventional” geothermal power

• Unique and successful set of project developments:
  – utilization of co-produced fluids
  – geo-pressured hybrid technology including waste heat to power
  – increasing technology transfer to the oil and gas industry

• First commercial use of ORC on “un-separated mixed hydrocarbons” - mid-stream oil production facility in CA

• Developing geopressured hybrid geothermal
  – low-moderate temperature geo-pressured fluids
  – recover the waste heat from the engine exhaust and jacket water
  – from burning entrained naturally occurring solution gas assets
“Un-separated mixed hydrocarbons”

• “Major’s” Problem statement:
  – Develop a waste heat recovery project
  – Using binary turbine technology
  – Convert waste heat into electricity
  – Hydrocarbon-water-multi-phase
  – Prior to separation
  – Mid-stream processing facility
“Un-separated mixed hydrocarbons”

<table>
<thead>
<tr>
<th>Constituent</th>
<th>C #</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methane</td>
<td>C-1</td>
</tr>
<tr>
<td>Ethane</td>
<td>C-2</td>
</tr>
<tr>
<td>Propane</td>
<td>C-3</td>
</tr>
<tr>
<td>Natural Gas Fraction</td>
<td></td>
</tr>
<tr>
<td>Butanes</td>
<td>C-4</td>
</tr>
<tr>
<td>Pentanes</td>
<td>C-5</td>
</tr>
<tr>
<td>Hexanes</td>
<td>C-6</td>
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<tr>
<td>Gasoline Fraction</td>
<td></td>
</tr>
<tr>
<td>Heptanes</td>
<td>C-7</td>
</tr>
<tr>
<td>Octanes</td>
<td>C-8</td>
</tr>
<tr>
<td>Nonanes</td>
<td>C-9</td>
</tr>
<tr>
<td>Gasoline Fraction</td>
<td></td>
</tr>
<tr>
<td>Decanes</td>
<td>C-10</td>
</tr>
<tr>
<td>Undecanes</td>
<td>C-11</td>
</tr>
<tr>
<td>Dodecanes</td>
<td>C-12</td>
</tr>
<tr>
<td>Kerosene Fraction</td>
<td></td>
</tr>
<tr>
<td>Tridecanes</td>
<td>C-13</td>
</tr>
<tr>
<td>Tetradecanes</td>
<td>C-14</td>
</tr>
</tbody>
</table>

### Constituent

- Oxygen/Argon O2 / Ar
- Nitrogen N2
- Carbon Dioxide CO2
- Carbon Monoxide CO
- Methane C-1
- Ethane C-2
- Propane C-3
- Iso-Butane C-4
- N-Butane C-4
- Neo Pentane C-5
- Iso-Pentane C-5
- N-Pentane C-5
- Hexanes Plus C-6 (+)
- Hydrogen H2
- Hydrogen Sulfide H2S

### Vapor Flow Rates

<table>
<thead>
<tr>
<th>Total</th>
<th>MSCF/Day</th>
<th>lb/hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas</td>
<td>MSCF/Day</td>
<td>lb/hr</td>
</tr>
<tr>
<td>Steam</td>
<td>BSPD</td>
<td>lb/hr</td>
</tr>
</tbody>
</table>

### Physical Data

- BTU cu.ft. ideal =
- BTU cu.ft. real =
- BTU/lb, ideal =
- (Density) Sp. Gr. Ideal =
- (Density) Sp. Gr. Real =
- Density lbm/(1000 ft³) =

### Dew Point (Water Content) Calculation

ASTM D 1142
(14.7 psia 80°F Base)

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“Un-separated mixed hydrocarbons”
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“Geopressed Hybrid”

• Been there – Done that....
  – Late 1980s, Ben Holt Co. designed, built, and operated a demo plant
  – Pleasant Bayou geopressured resource

• The power plant operated successfully...
  – Electricity could be generated from geopressed resources
  – With high reliability, using standard materials of construction

• Using a hybrid cycle...
  – Electricity generated by burning entrained gas in engines
  – heat from the gas engine exhaust supplements heat from the brine
  – improve efficiency of the binary cycle

• The project was co-funded by the U.S. Department of Energy and the Electric Power Research Institute.
SUCCESS!!!

• Nominal 1.0 MW hybrid cycle (10,000 BPD)
• Multiple energy streams - running on brine and gas

The hybrid cycle power plant demonstrated that there are no technical obstacles to electricity generation.

The hybrid power system demonstration at Pleasant Bayou was successful in all respects.
“Geopressured Hybrid”
“Geopressured Integrated Hybrid”

TAS ENERGY – Developments in the Gulf Coast Region...

- Binary w/ “Un-separated mixed hydrocarbons” HEX
- Recover waste heat from engine exhaust & jacket water
- Substantial efficiency improvements
- **Nominal 3.5 MW Integrated Hybrid Cycle (25,000 BPD)**
Generating electricity from multiple energy streams

- Reduces overall project expenses
- Reduces or eliminates CO2 emissions
- Decreases operator dependency on the local grid
- May qualify for Renewable Energy Credits
- Combining surface & reservoir sources of thermal energy maximizes the opportunity for Return on Investment.
Questions
Thank You!

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