Advantages of In-situ Gas Extraction

Dr. Kevin Shurtleff
Dr. Milind Deo

MOUNTAIN WEST ENERGY

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U.S. Energy Facts

U.S. Primary Energy Consumption by Source and Sector, 2005 (Quadrillion Btu).
MWE’s Oil Shale Strategy

“Those who do not learn from the past are doomed to repeat it.”
[George Santayana]

“I’ve missed almost 9,000 shots. I’ve lost almost 300 games. I’ve failed over and over again in my life. And that is why I succeed.”
[Michael Jordan]

We are fortunate to learn from the failures and build on the successes of the those that have blazed the path.
Oil Shale Issues

- The quantity of oil shale is well documented.
- Oil from oil shale is technically feasible.
- Critical issues today are economic and environmental.
- Commercial viability requires the following:
  1. Low capital and operating costs.
  2. Fast return on investment (ROI).
  3. Low environmental impact.
Why in-situ?

- Lowest cost
- Lowest environmental impact
- Safest

In-situ methods produced 289,000 bbls/day of oil from Canadian oil sands in 2005.

The in-situ conversion process (ICP™) showed us the possibilities for oil shale.
MWE In-situ Gas Extraction

- Closed loop, re-circulating gas.
- Faster heating by convection.
- Oil vapor (not liquid).
- Inverted flow (extraction point above injection point).
- Single well.
Pyrolysis Thermodynamics

Thermodynamic equilibrium calculations using HSC (Outokumpu Research).

Pyrolysis of a large paraffin molecule (C40H82) at 1300 psia.

Pyrolysis is kinetically limited.
Pyrolysis Kinetics

M.D. Lewan and T.E. Ruble, Organic Geochemistry, 33, (2002), 1457-1475

Slow, low temperature, high pressure, natural process produces the highest quality oil.

Fig. 19. Temperature-pressure plot showing conditions employed by open-system pyrolysis, hydrous pyrolysis, and natural oil generation relative to the vapor-liquid (v/l) phase curves and critical points (CP) for n-pentadecane (a) and water (b).
Pyrolysis Energy Requirements

1 acre of oil shale (235 ft diameter x 100 ft thick)
= 291,500 tons (long)
= 168,013 GJ to heat to 350 C with 10% heat loss (not including heat of cracking/reaction).
= 1.95 GW over a day, 2.66 MW over two years, 1.07 MW over five years.
= Natural gas cost of ~ $955,471 ($6 per mmBtu) or electricity cost of ~ $2,800,209 ($0.06 per kWhr)
= Potential to produce ~152,700 bbls of oil (22 gal/ton).
Single Well Process

- Low surface impact (chemistry underground).
- Each well covers ~ ¾ acre
- Oil extracted over 2 years (fast recovery).
- 60,000+ barrels per well at 50% extraction efficiency.
- Total direct costs for a single well project ~ $800,000.
Why Utah?
Preventing Groundwater Contamination


(Brian Black)
Environmental Impact

- IGE requires 14 wells to cover a 10 acre plot. Almost 300 wells, spaced 8 ft, are required to surround a 10 acre plot.
- Natural gas heaters for IGE will produce 9,341 metric tons of carbon dioxide (90% conversion efficiency). Electric heaters will produce 37,217 metric tons of carbon dioxide from a coal fired power plant (40% conversion efficiency).
- IGE enables heat capture from previously depleted zones, to reduce energy costs and emissions.
- IGE could use solar thermal heating to reduce energy costs and eliminate most emissions.
Why Natural Gas?

- Natural gas is readily available near oil shale deposits in the Uintah Basin of Utah.
- Natural gas produced during pyrolysis can be re-circulated without separation.
- Natural gas produced by pyrolysis can be directly burned to generate heat for the process.

Carbon dioxide would work, but requires additional equipment for separating natural gas from the re-circulating gas.
Steam is a better heat carrier (heat of vaporization), but condenses to liquid in the formation. Does the oil float?
Fracturing for Gas Flow

- Thermal fracturing
- Hydraulic stimulation
- Gas Gun™
- High pressure gas fracturing
- Methane solubility – No fracturing required?

Fracturing occurs perpendicular the least principal stress. In shallow oil shale formations, this may result in horizontal fractures.
Slope differences suggests methane solubility is ~2x greater than nitrogen solubility (non-isothermal conditions).

Test system has been enhanced with constant temperature controller.
Laboratory Scale System

- Functioning system.
- Parameters
  1.8 kg of Utah oil shale
  99% recirculating methane
  Gas temp. = 350 - 400 °C
- Results
  0.11 kg of oil (6 wt%)
  API gravity 18-21
  Sulfur content 0.5-1.0 wt%
  Wax content 3.9 wt%
  Hydrogen/Carbon ratio 1.6
  (Conventional oil = 1.9)
- Experimentation is on-going
RMOTC Project

Naval Petroleum Reserve #3, Teapot Dome, Shannon Formation
Phase 1 – gas flow testing
Phase 2 – heating and oil extraction
Starting Fall 2007
MWE’s Competitive Advantages

- Lowest capital and operating costs.
- Scalable by replication.
- Faster return on investment.
- Marketable oil without upgrading.
- Low environmental impact.
- Five patents in process.

(Low cost truck mounted rig)
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Questions