SHALE GAS WILL DRIVE INNOVATION IN TRANSPORT FLUIDS

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Shale Gas in the US

The Marcellus is close to major east coast demand.

Photo Source: U.S. Energy Information Administration
What Changed the Game?

- “Source Rock” was not considered for production unless naturally fractured
- Recognition that multi-stage **hydraulic fracturing** could create a “permeable reservoir” changed the game
- **Horizontal drilling** provided more drainage volume per foot drilled: reduced cost

Photo source: SPE Shale Course, George E. King and Ian Palmer
## Shale Gas Environmental Concerns

<table>
<thead>
<tr>
<th>Concern</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contamination of aquifers</td>
<td>Sound drilling practice</td>
</tr>
<tr>
<td></td>
<td>Regulatory oversight</td>
</tr>
<tr>
<td>Fresh water withdrawals</td>
<td>Recycle frac water</td>
</tr>
<tr>
<td></td>
<td>Use saline water</td>
</tr>
<tr>
<td>Flow back water disposal</td>
<td>Recycle frac water</td>
</tr>
<tr>
<td></td>
<td>Deep Disposal Wells</td>
</tr>
<tr>
<td>Chemicals in fracture fluid</td>
<td>Greener chemicals</td>
</tr>
</tbody>
</table>
GOAL OF ZERO DISCHARGE AND ZERO WITHDRAWALS

REQUIRES

• Salt Tolerance
  • Allows easier re-use of flowback water
  • Allows use of saline waters of convenience

• Addressing Potential Issues with High Salt
  • Scaling: can be repository for radioactive species
  • Divalent ions can retard efficacy of cross-linkers, friction reducers
  • Reservoir effects need better definition
  • More desalination may be needed than with fresh water make up
SALINE WATERS OF CONVENIENCE

• **Sea Water**
  • Simplest to process
  • TDS average of 35000 ppm is already acceptable

• **Saline Aquifers**
  • Target shallow ones preferably for easy access and lower salinity
  • USGS has not mapped since middle of last century (see map)
  • Available maps show presence in many shale gas areas
  • Withdrawal could affect hydrology of proximal fresh bodies

• **Produced Water**
  • Potentially the most challenging
  • But use offsets need to dispose of
Shale Gas Environmental Solutions

• Multiple wells from single pad reduces environmental footprint, improves operational and regulatory oversight
• Zero discharge target is achievable with water handling and processing technologies
  – Explore deep disposal: low cost when feasible
• Greening of fracture fluid chemicals is a tractable near term goal
• Needed: Industry innovation and transparency combined with community willingness to listen and cooperate
The Energy Transition—About 10 Years Away

Demand Must Fall—Unless Alternatives Can Fill the Gap

World Oil Balance

- Production
- Domestic Demand incl. Bunkers
- Net Imports incl. Bunkers

mmbd

Private Vehicles—the Heart of the Problem
Growth in Non-OECD Car Fleet Just Beginning

Cars per 1000 People
Historical Data through 2003/04

The Oil Case for Electrification | Electrification of Transport | Page 5
REPLACING OIL WITH GAS

• Gas, oil prices historically volatile
  – Gas: $2-12 per MMBTU (see graph)
  – Oil: $40-140 per barrel
  – Uncertainty hurts switches to gas

• Shale gas changed the game
  – Cost expected to be moderate and stable
  – Demand drives floor, fast new capacity assures ceiling

• Oil/gas price ratio today about 4
  – Expect to remain high
  – Will drive gas derived transport fuel solutions
REPLACING OIL WITH GAS (contd.)

• **CNG for transport fuel**
  – 4x volume of diesel tank
  – public transport

• **LNG for long haul, trains**
  – 1.4x volume of diesel
  – Infrastructure needed

• **Gas to liquids**
  – Technology needed to improve economics
  – Gasoline the preferred target
North Carolina Implications

• Investigate shale gas potential
  – Labor intensive
• Modify laws to allow: horizontal drilling, fracturing
• Address environmental issues from outset
  – Saline water resource estimation
  – Deep disposal feasibility study
  – Set zero discharge targets and timeline
  – Regulatory oversight on well quality
  – Pad drilling for all but early stage development
North Carolina Implications (contd.)

- **Investigate gas to liquids**
- **Companion with biomass to liquids**
  - Technology identical after syngas production step
- **Modify state fuel import reduction targets**
  - Allow NG for transport as valid contribution
  - Only for domestic natural gas?