Benefits & Costs of Hydraulic Fracturing in shale Gas Production

November 2013
Perth, Australia
Schematic geology of natural gas resources

Conventional non-associated gas

Land surface

Coalbed methane

Conventional associated gas

Seal

Tight sand gas

Gas-rich shale

Map of basin with assessed shale gas
Shale Gas Introduction

Top 10 countries with technically recoverable shale gas resources

<table>
<thead>
<tr>
<th>Rank</th>
<th>Country</th>
<th>Shale gas (trillion cubic feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>China</td>
<td>1,115</td>
</tr>
<tr>
<td>2</td>
<td>Argentina</td>
<td>802</td>
</tr>
<tr>
<td>3</td>
<td>Algeria</td>
<td>707</td>
</tr>
<tr>
<td>4</td>
<td>U.S.</td>
<td>665</td>
</tr>
<tr>
<td>5</td>
<td>Canada</td>
<td>573</td>
</tr>
<tr>
<td>6</td>
<td>Mexico</td>
<td>545</td>
</tr>
<tr>
<td>7</td>
<td>Australia</td>
<td>437</td>
</tr>
<tr>
<td>8</td>
<td>South Africa</td>
<td>390</td>
</tr>
<tr>
<td>9</td>
<td>Russia</td>
<td>285</td>
</tr>
<tr>
<td>10</td>
<td>Brazil</td>
<td>245</td>
</tr>
</tbody>
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**World Total** 7,299  (7,795)
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Natural gas is the cleanest burning fossil fuel
• in US, between 20 and 40 deaths annually, between 10 and 20 for oil and gas extraction.
• 520-1040 gallons of water are required per MWh of coal
• gas-fired combined cycle power requires 130-500 gallons per MWh.
Shale gas is an excellent substitute for conventional natural gas
Another Power-out Day
Hydraulic Fracturing Process

- Well bore
- Fracturing Fluid
  - Water
  - Sand
  - Additives
- Pumping (HP)
- Fractures
- Gas flow to well bore
- Water recover and treatment
In Barnett Shale gas field (in Texas of U.S):

- Median Water use per well in 2009 - 2011: \( \frac{10600 \text{ M3}}{2500} = ??? \)
Cost & Risk – Water Contamination
Cost & Risk – Litigation

[Map showing pending hydraulic fracturing lawsuits, complaints by state.
- Pennsylvania: 9
- Arkansas: 8
- Texas: 10
- Other states with complaints: Colorado, New York, West Virginia, Louisiana, and others.

Source: Oil & Gas Journal | Dec. 5, 2011]
Cost & Risk – Operation Cost

2006-2010 US
• Median Cost: $600,000 /Well
• Extreme Cost: $1.5–2.5 million /Well
Hydraulic Fracturing

Benefits

Costs & Risks
Suggestions to control the Costs & Risks of hydraulic fracturing

• **Suggestion for water usage**

  - Brackish Water
  - Produced Water
  - Water Pipeline
  - Less Water-intensive Technologies
  - Fracturing Fluid Recycle
Suggestions to control the Costs & Risks of hydraulic fracturing

• **Suggestions to prevent environment pollution**

  - **Leaking**

    - Monitor and control potential leaking possibility.
    - Upgrade storage and transport systems.
    - Inject tracers with the fracturing fluid.
Suggestions to control the Costs & Risks of hydraulic fracturing

• **Suggestions to prevent environment pollution - Leaking**

  Setting up isolation regions.
  Helping original dwellers to migrate out of the shale gas extraction regions.
Suggestions to control the Costs & Risks of hydraulic fracturing

• **Suggestions to prevent environment pollution**

  - **Additives**

  Some of these additives are relatively benign which are common used in household products.

  Some of these additives may be substituted by non-toxic ones, or to be improved or modified through technique innovation.
Suggestions to control the Costs & Risks of hydraulic fracturing

• **Suggestions to prevent environment pollution**

Regulations, rules, and laws for shale gas exploitation should be carried out as soon as possible.

Only in this way, the sustainable future of shale-gas extraction can be ensured.
Suggestions to control the Costs & Risks of hydraulic fracturing

• **Suggestions to face with litigation**
  1. Comply with environmental regulations.
  2. Prepare to respond to increased litigation.

• **Suggestions for financial cost**
  1. Hydraulic fracturing is better than drill more wells.
  2. The price of nature gas is increasing rapidly.
  3. Hydraulic fracturing technique improvement and innovation.
Conclusions

We deem that the investment, output, and the proportion of shale gas in the world energy consumption will increase steadily, and shale gas is destined to play a more and more important role in many countries (including China) and regions.
Thank you!