Unconventional Oil and Gas

Global Perspective

Stephen A. Holditch
April 2014
World Energy Supply-History and Projected (IEA, 2010)

2008—12,271 Mtoe per year

2035—16,765 Mtoe per year
Outline

• What are unconventional reservoirs?
  ▪ Resource Triangle
  ▪ History in North America

• What are the global implications?
  ▪ Correlations from North America
  ▪ Extrapolation to rest of the world

• Conclusions
Resource Triangle

Conventional Reservoirs
Small volumes that are easy to develop

Unconventional
Large volumes difficult to develop

Increased pricing
Improved technology
Implications

- All natural resources are distributed log normally – gold, silver, oil, gas, etc.
- The high grade deposits are difficult to find but easy to extract
- As you get deeper into the resource triangle, you need adequate product prices and improved technology
Implications

• Low quality reservoirs can be enormous
• There should be a log normal distribution of resources by quality in every oil and gas basin we now produce
• Thus, there should be very large volumes of gas and oil in unconventional reservoirs around the world
Outline

• What are unconventional reservoirs?
  ▪ Resource Triangle
  ▪ History in North America

• What are the global implications?
  ▪ Correlations from North America
  ▪ Extrapolation to rest of the world

• Conclusions
North American shale plays
(as of May 2011)

Source: U.S. Energy Information Administration based on data from various published studies. Canada and Mexico plays from ARI.
Updated: May 9, 2011
Shale gas leads growth in total gas production through 2040 to reach half of U.S. output

U.S. dry natural gas production
trillion cubic feet

Source: EIA, Annual Energy Outlook 2013

Adam Sieminski, Deloitte, May 21, 2013
U.S. tight oil production leads growth in domestic production

Reference case

High resource case

Source: EIA, Annual Energy Outlook 2013 and Short-Term Energy Outlook, May 2013

Adam Sieminski, Deloitte, May 21, 2013
Outline

• What are unconventional reservoirs?
  ▪ Resource Triangle
  ▪ History in North America

• What are the global implications?
  ▪ Correlations from North America
  ▪ Extrapolation to rest of the world

• Conclusions
Last Global Unconventional Gas Assessment Is Now Conservative

- New emergence of UG plays around the world since 1997
- Uncertainty of Rogner’s assessment was not quantified

<table>
<thead>
<tr>
<th>Regions</th>
<th>CBM OGIP, Tcf</th>
<th>Shale OGIP, Tcf</th>
<th>Tight Sands OGIP, Tcf</th>
<th>Total, Tcf</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia &amp; Asia (AAO)</td>
<td>1,724</td>
<td>6,151</td>
<td>1,802</td>
<td>9,677</td>
</tr>
<tr>
<td>North America (NAM)</td>
<td>3,017</td>
<td>3,840</td>
<td>1,371</td>
<td>8,228</td>
</tr>
<tr>
<td>Commonwealth of Independent States (CIS)</td>
<td>3,957</td>
<td>627</td>
<td>901</td>
<td>5,485</td>
</tr>
<tr>
<td>Latin America (LAM)</td>
<td>39</td>
<td>2,116</td>
<td>1,293</td>
<td>3,448</td>
</tr>
<tr>
<td>Middle East (MET)</td>
<td>0</td>
<td>2,547</td>
<td>823</td>
<td>3,369</td>
</tr>
<tr>
<td>Europe (EUP)</td>
<td>274</td>
<td>549</td>
<td>431</td>
<td>1,254</td>
</tr>
<tr>
<td>Africa (AFR)</td>
<td>39</td>
<td>274</td>
<td>784</td>
<td>1,097</td>
</tr>
<tr>
<td>World</td>
<td>9,051</td>
<td>16,103</td>
<td>7,405</td>
<td>32,559</td>
</tr>
</tbody>
</table>

Introduction

Data Source: Rogner, 1997
Resource Triangle

Conventional Reservoirs
Small volumes that are easy to develop

Unconventional
Large volumes difficult to develop

Increased pricing
Improved technology
North American shale plays
(as of May 2011)

Source: U.S. Energy Information Administration based on data from various published studies. Canada and Mexico plays from ARI.
Updated: May 9, 2011
Methodology to Update Global Unconventional OGIP Assessment

- Evaluated global conventional OOIP and OGIP from published data
- Collected public data for North American unconventional gas resources
- Assessed global unconventional OGIP by
  - Developing theoretical statistical relationships between conventional hydrocarbons and unconventional gas
  - Fitting these relationships to North American publically available data
  - Applying North American theoretical statistical relationships of conventional to unconventional gas to estimate world unconventional gas
## Texas A&M Study Results
### From Zhenzhen Dong Dissertation – August 2012

<table>
<thead>
<tr>
<th>Region</th>
<th>OGIP (P50), Tcf</th>
<th>TRR (P50), Tcf</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CBM</td>
<td>Tight gas</td>
</tr>
<tr>
<td>AAO</td>
<td>1,348</td>
<td>6,253</td>
</tr>
<tr>
<td>NAM</td>
<td>1,629</td>
<td>10,784</td>
</tr>
<tr>
<td>CIS</td>
<td>859</td>
<td>28,604</td>
</tr>
<tr>
<td>LAM</td>
<td>13</td>
<td>3,366</td>
</tr>
<tr>
<td>MET</td>
<td>9</td>
<td>15,447</td>
</tr>
<tr>
<td>EUP</td>
<td>176</td>
<td>3,525</td>
</tr>
<tr>
<td>AFR</td>
<td>18</td>
<td>4,000</td>
</tr>
<tr>
<td>World</td>
<td>4,052</td>
<td>71,981</td>
</tr>
</tbody>
</table>
Centuries of Natural Gas Supply

Recent research at TAMU has computed natural gas resource estimates for tight sands, coal seams and shales.

<table>
<thead>
<tr>
<th>Area</th>
<th>OGIP (Tcf)</th>
<th>TRR (Tcf)</th>
<th>USE (Tcf)</th>
<th>Supply (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>North America</td>
<td>18,318</td>
<td>8,614</td>
<td>32</td>
<td>269</td>
</tr>
<tr>
<td>World</td>
<td>125,742</td>
<td>57,641</td>
<td>118</td>
<td>488</td>
</tr>
</tbody>
</table>
Centuries of Natural Gas Supply

• Not all of the TRR is Economically Recoverable (ERR) at todays prices and using todays technology
• However, at least 25 – 50% of the TRR should be converted to ERR as prices rise, technology improves and markets develop
• Conclusion – We are not going to run out of resource – oil or natural gas any time soon.
Outline

• What are unconventional reservoirs?
  ▪ Resource Triangle
  ▪ History in North America

• What are the global implications?
  ▪ Correlations from North America
  ▪ Extrapolation to rest of the world

• Conclusions
Conclusions

• Natural Resources are distributed log normally in nature
• In every basin that has produced substantial quantities of conventional oil and gas, there is much more left in unconventional reservoirs
• Current development is from source rocks
• We will not run out of producible hydrocarbons this century