SHALE HYDROCARBON RESOURCES OF WEST VIRGINIA

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Governor Tomblin’s ENERGY Summit
West Virginia: Committed to a Sound Energy Future

Stonewall Resort October 27, 2015
Outline

• Marcellus Shale:
  • Geology and Engineering
  • In-place and recoverable resource
• Utica Shale:
  • Current activity
  • Resource
• What’s next?
  • Rogersville: Geology and Challenges
  • Horizontal drilling in old reservoirs
• Getting it to market: New pipelines
STRUCTURAL CROSS-SECTION FROM HARRISON CO., OHIO TO HARDY CO., WEST VIRGINIA

Ray Boswell, NETL
DISCLAIMER: These maps are preliminary drafts which reflect data and analyses current as of September 14, 2015. The maps will likely change as additional data become available and techniques are refined. Users are cautioned that these maps represent only a best estimate of trends given available data and should not be used as a stand-alone product.
Marcellus Shale
Original Gas In-Place Volume Per Unit Area

Marcellus Shale Resource Assessment
Original Gas-In-Place Estimate
(in Bcf/m²)

Natural Gas Volume
Volume/Area

0.4 - 2
2 - 5
5 - 9
9 - 15
15 - 25
~Sweet Spot

Bcf=billion cubic feet

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October 27, 2015
### Marcellus Resource

<table>
<thead>
<tr>
<th>Resource</th>
<th>Source</th>
<th>Gas (Tcf) Minimum</th>
<th>Gas (Tcf) Average</th>
<th>Gas (Tcf) Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remaining Recoverable</td>
<td>U.S. Geological Survey (2011)</td>
<td>-</td>
<td>18.5</td>
<td>-</td>
</tr>
<tr>
<td>Original In-Place</td>
<td>West Virginia Geological Survey</td>
<td>119.6</td>
<td>142.3</td>
<td>165.3</td>
</tr>
<tr>
<td>Recovery Factor</td>
<td></td>
<td>15%</td>
<td>13%</td>
<td>11%</td>
</tr>
</tbody>
</table>

*Tcf = Trillion cubic feet*
*Point Pleasant=primary “Utica Shale” resource
Utica Resource
Original Gas In-Place Volume Per Unit Area*

MMbo=million barrels oil; Bcf=billion cubic feet
*average volume per square mile in the “sweet spot” area

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Utica Resource
Original Gas In-Place Volume Per Unit Area*

MMbo=million barrels oil; Bcf=billion cubic feet
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## Utica Resource

<table>
<thead>
<tr>
<th>Region</th>
<th>Volume*</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Oil (Bbo)</td>
<td>Gas (Tcf)</td>
</tr>
<tr>
<td><strong>Remaining Recoverable</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>West Virginia</td>
<td>N/A</td>
<td>97</td>
</tr>
<tr>
<td>Appalachian Basin</td>
<td>2.6</td>
<td>890</td>
</tr>
<tr>
<td><strong>Original In-Place</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>West Virginia</td>
<td>N/A</td>
<td>271</td>
</tr>
<tr>
<td>Appalachian Basin</td>
<td>83</td>
<td>3,192</td>
</tr>
</tbody>
</table>

**Current Overall Recovery Factor**

- 3%
- 28%

_Bbo=Billion barrels oil; Tcf=Trillion cubic feet_*

*estimated volume in the “sweet spot” area; **remaining technically recoverable_
## Utica Resource

<table>
<thead>
<tr>
<th>Stratigraphic Unit</th>
<th>Region</th>
<th>Original In-Place Resources, Total Volume</th>
<th>West Virginia Resource as Percentage Of Appalachian Basin</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Oil (MMbo)</td>
<td>Gas (Bcf)</td>
</tr>
<tr>
<td>Utica Shale</td>
<td>West Virginia</td>
<td>N/A</td>
<td>48,879</td>
</tr>
<tr>
<td></td>
<td>Appalachian Basin</td>
<td>43,508</td>
<td>1,098,119</td>
</tr>
<tr>
<td>Point Pleasant Formation</td>
<td>West Virginia</td>
<td>N/A</td>
<td>203,465</td>
</tr>
<tr>
<td></td>
<td>Appalachian Basin</td>
<td>33,050</td>
<td>1,745,803</td>
</tr>
<tr>
<td>Logana Member of Trenton Limestone</td>
<td>West Virginia</td>
<td>N/A</td>
<td>18,857</td>
</tr>
<tr>
<td></td>
<td>Appalachian Basin</td>
<td>6,345</td>
<td>348,476</td>
</tr>
</tbody>
</table>

*MMbo=million barrels oil; Bcf=billion cubic feet*
Rogersville Shale

An Opportunity?
• Organic-rich shale
• Thick
• Favorable mineralogy

But:
• Deep
• Faulted
• Poorly mapped

Hickman, Harris and Eble, Kentucky Geological Survey
# Horizontal Wells Completed and Active Permits (Excluding Marcellus)

<table>
<thead>
<tr>
<th>Target Formation</th>
<th>Completions 2006-present</th>
<th>Active Permits issued after 9/30/2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Berea Sandstone</td>
<td>15</td>
<td>42</td>
</tr>
<tr>
<td>Big Injun</td>
<td>10</td>
<td>27</td>
</tr>
<tr>
<td>Burket Shale/Geneseo Shale</td>
<td>16</td>
<td>58</td>
</tr>
<tr>
<td>Lower Huron</td>
<td>445</td>
<td>8</td>
</tr>
<tr>
<td>Middlesex Shale</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Upper Devonian</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>Utica Shale/Point Pleasant Fm.</td>
<td>5</td>
<td>14</td>
</tr>
</tbody>
</table>

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Major Proposed Pipeline Projects in West Virginia

Proposed Pipeline Projects
- Atlantic Coast
- Header Supply Project
- Leach Xpress
- Mariner East 2
- Mountain Valley
- Mountain Valley Alternative Route
- Mountaineer Xpress
- Rover
- Stonewall Gas Pipeline Project
- Tennessee Gas Expansion
- Western Marcellus

Prepared by Philip Dinterman & Samantha Mccreaey, October 2016
Thank you and have a safe trip home!

For more information:
http://www.wvgs.wvnet.edu/