THE MARCELLUS SHALE LEARNING CURVE:
RESULTS AND CHALLENGES

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Evaluating Eastern shales is nothing new to us at Wright & Company, Inc.

UNCONVENTIONAL
- Devonian Shales Including Marcellus
- Coal Bed Methane
- Tight Gas Sands

“RELIABLE TECHNOLOGY”
- Vertical
- Horizontal
- Fracture Techniques
PENNSYLVANIAN-DEVONIAN-MARCELLUS OVERVIEW

DEVONIAN
- First commercial gas well – 1821
- Thousands of wells drilled
- Tight gas sands

CBM
- Vertical
- Horizontal
- Multilaterals
- Patterns

MARCELLUS
- Covers 65+ million acres
- Close proximity to premium markets
- Extends throughout eight states
- May ultimately be the largest natural gas field in the U.S.
- Over 500 Tcfe in place per Engelder and Lash study

WHERE IS THE MARCELLUS SHALE?

## LARGEST LEASEHOLDERS

<table>
<thead>
<tr>
<th>COMPANY</th>
<th>STOCK SYMBOL</th>
<th>APPROX NET MARCELLUS ACREAGE</th>
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<tbody>
<tr>
<td>Chesapeake Energy</td>
<td>CHK</td>
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<td>Range Resources</td>
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<td>NFG/Seneca Resources</td>
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<td>Dominion Resources</td>
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<td>Chief Oil &amp; Gas</td>
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<td>AB Resources</td>
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<td><strong>TOTAL</strong></td>
<td></td>
<td><strong>9,244,000</strong></td>
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*Source: Public Records*
WV & PA MARCELLUS WELLS
(permited and/or drilled as of September 30, 2009)

Source: Pennsylvania DEP, West Virginia Geological and Economic Survey
SW PA & WV OPERATORS

- RANGE RESOURCES: Drilled 42 horizontal wells and 75 vertical wells.
- EQUITABLE RESOURCES: Drilled 3 horizontal first completion test, average 1.9 MMcfpd.
- CHESAPEAKE: Announced 9 MMcfpd from 2 horizontal completions combined.
- ATLAS RESOURCES: Drilled 138 vertical wells and 7 horizontal wells (3 producing).
- CNX: First vertical tested 1.3 MMcfpd. First horizontal well completed at 6.5 MMcfpd maximum rate.
**NE PA OPERATORS**

- **EOG** - Drilled 2 horizontal wells expecting 2 BCF per well.
- **CABOT** - ~20 wells total producing 21 MMcfpd; 4 horizontal IPs of 6.4, 8.3, 8.8 & 9 MMcfpd.
- **CHESAPEAKE** - 12 vertical wells on-line with combined rate of ~5 MMcfpd; and 6 horizontal wells on-line with combined rate of ~10 MMcfpd; tested 6.5 MMcfpd in horizontal.
- **RANGE** - Drilled 4 vertical & 1 horizontal well; vertical IP rates of 2.3 to 6.3 MMcfpd.
- **EXCO** - Drilled 2 horizontal wells 1.0 to 2.6 MMcfpd initial rates.

*Wright & Company, Inc.*
*Petroleum Consultants*
MARCELLUS DEVELOPMENT TIMELINE
(as of September 30, 2009)

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Wells Drilled</th>
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<tbody>
<tr>
<td>2004</td>
<td>50</td>
</tr>
<tr>
<td>2005</td>
<td>100</td>
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<tr>
<td>2006</td>
<td>150</td>
</tr>
<tr>
<td>2007</td>
<td>200</td>
</tr>
<tr>
<td>2008</td>
<td>250</td>
</tr>
<tr>
<td>2009</td>
<td>300</td>
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</table>

Source: Pennsylvania DEP
WHAT WE KNOW ABOUT THE MARCELLUS

- The Marcellus Shale covers a large area and has a tremendous volume of original gas in place.

- Development is in its infancy.

- Initial results are very encouraging.

- The Marcellus is a unique shale.

- Bigger may not necessarily always be better for the Marcellus.

- Lessons from the Barnett Shale model have accelerated the development of the Marcellus.

- Not all 65 million acres are created equal.

- Not all acres will be “economically” producible; OGIP, rock quality, and location are critical.
WHAT WE ALSO KNOW BY REVIEWING EARLY RESULTS

• Gross shale isopach may not correlate to productivity.
• Porosity and permeability are key to productivity.
• IP may not necessarily relate directly to EUR.
• Type curves tend to look similar for shales.
  • Several “b” factors; initial declines; EURs on public websites
  • Difference depends on location and reservoir quality
  • Drilling and completion techniques
• Well results are widely distributed.
  • Vertical – less than 0.200 up to 1.2 Bcfe
  • Horizontal
    • Initially 2.5 – 3.3 Bcfe
    • More recently 3.5 – 5+ Bcfe
    • Averages now claimed to be 3.9 – 4.4 Bcfe
THE MARCELLUS SHALE LEARNING CURVE

PHASE I
Exploratory
(Defining Reservoir Parameters)

PHASE II
Research & Development
(Reasonable Certainty, Reliable Technology)

PHASE III
Exploitation & Optimization
(Consistency, Repeatability, Economically Producible)

Number of Wells Drilled
Knowledge and experience gained in other shales are helpful, but each has its own learning curve.
**Vertical Well Program**

- test acreage
- determine characteristics of reservoir
- wet vs. dry area
- over or under-pressured
- faulting – natural fracture orientation
- completion techniques
THE MARCELLUS SHALE LEARNING CURVE

Geoscience (Defining Reservoir Parameters)

- depth
- thickness of shale
- total organic content (TOC)
- porosity
- pressure
- permeability
- gas analysis
- natural fractures
- original gas in place (OGIP)
THE MARCELLUS SHALE LEARNING CURVE

Regulatory Concerns

- permitting to drill – vertical and horizontal
- ground water protection
- recent changes in PA and NY
- unique by state
- expanded environmental considerations
- water management
  - withdrawal
  - treatment
  - disposal
  - recycling
REGULATORY CHALLENGES

• Discussions between Marcellus operators and regulators have had positive results.

• Recent changes/status in regulations
  • PA re-wrote the regulations within six months; permitting is now at 45 days.
  • NY issued its long-awaited draft plan for regulations on October 2, 2009.
  • WV has been accommodating to the development of the Marcellus.

• Water everywhere, but none to use
  • Any water usage in Susquehanna watershed requires approval by that agency along with state agency.
  • Community meetings to discuss environmental impact

• Limited disposal wells in Northern Pennsylvania
  • Current cost of water hauling is significant.
  • Water salinity increases with time exposed to Marcellus which increases complexity of treatment.
REGULATORY AGENCIES

• Susquehanna Water District
  www.srbc.net

• Pennsylvania Dept. of Environmental Protection
  www.depweb.state.pa.us/dep/site/default.asp

• West Virginia Dept. of Environmental Protection
  www.wvdep.org

• New York State Dept. of Environmental Conservation
  www.dec.ny.gov

• Delaware River Basin Commission
  www.state.nj.us/drbc
ASSUMPTIONS

WI = 100%
NRI = 85%
D&C cost = $1.5 MM
LOE = $1,250/month
NO lease bonus costs included
water hauling and disposal = $7/bbl
dry gas only
location dependent
depth dependent
THE MARCELLUS SHALE LEARNING CURVE

Number of Wells Drilled

**PHASE I**
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(Defining Reservoir Parameters)

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THE MARCELLUS SHALE LEARNING CURVE

Horizontal Drilling Program

- lease configuration
- orientation to fractures
- lateral placement
- development spacing

Number of Wells Drilled
Drilling

- efficient utilization of drilling rig
- vertical – may continue to optimize development
- horizontal - multilateral
- pad system for drilling
- lateral placement
  - upper
  - middle
  - lower
- lateral length (2,000 to 5,000 feet)
THE MARCELLUS SHALE LEARNING CURVE

Completion Techniques

• frac design
  • volume of proppant
  • pump rates
  • sand concentrations
  • fluid type
  • number of stages
• mechanical considerations
**ASSUMPTIONS**

- **WI** = 100%
- **NRI** = 85%
- **D&C cost** = $4.5 MM
- **LOE** = $3,000/month
- No lease bonus costs included
- Water hauling and disposal = $6/bbl
- Dry gas only
- Location dependent
- Depth and lateral length dependent

**Graph:**
- **Rate of Return (%)** on the y-axis
- **Price per MMBtu** on the x-axis
- Lines for different volumes of natural gas (Bcfe): 6 Bcfe, 5 Bcfe, 4 Bcfe, 3 Bcfe
PHASE I
Exploratory
(Defining Reservoir Parameters)

PHASE II
Research & Development
(Reasonable Certainty, Reliable Technology)

PHASE III
Exploitation & Optimization
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THE MARCELLUS SHALE LEARNING CURVE

Infrastructure and Marketing in Place

• roads
• pipelines
• water procurement, usage and disposal
• gas treatment plants
• gathering
• compression
Economy of Scale – Cost Reduction

- effective drilling
  - pad – multiple wells
  - multilateral
  - completion
  - custom rigs
- lower cost per unit of production
The Marcellus Shale Learning Curve

Statistical Optimization
- decline curve analysis
  - type curve
    - “b” factor
    - initial rate/decline
  - average EUR
- PUD, PROB, POSS (3P) assignments
PHASE III – HORIZONTAL OPTIMIZATION ROR

ASSUMPTIONS

- WI = 100%
- NRI = 85%
- D&C cost = $3.5 MM
- LOE = $3,000/month
- NO lease bonus costs included
- water hauling and disposal = $6/bbl
- dry gas only
- location dependent
- depth and lateral length dependent

Price per MMBtu

Rate of Return (%)
WHAT THE FUTURE HOLDS FOR THE MARCELLUS

Wright & Company, Inc. expects the development to become a “statistical” play.

• Over time, the results should continue to improve.
• The “economy of scale” should reduce costs.
  • Lower drilling and completion costs
  • Improvement in operational methods
• Clearer definition of Core, Tier 1, Tier 2, other
• Success largely determined by OGIP and rock quality
• Winners will have commitment and financial capacity.
  • Strong and experienced technical team
  • Rigs and service capabilities
  • Good relationship with state and local governments
  • Infrastructure for gathering and processing
  • Transportation take away capacity
THE MARCELLUS SHALE LEARNING CURVE

- **Cost per Mcfe**
- **Number of Wells Drilled**
- **Average EUR**
“You may work harder and harder at climbing the ladder of success only to discover you are leaning against the wrong wall. If the ladder is not leaning against the right wall, every step we take just gets us to the wrong place faster.”

(Stephen Covey, The 7 Habits of Highly Effective People)
THANK YOU!

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