16th Annual Tulane Engineering Forum
How the Louisiana Upstream and Downstream Oil and Gas Business Benefits from Technology Developments

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Managing Director

Tulane University
Bachelor of Science, Mechanical Engineering, 1981
Master of Engineering, Petroleum Engineering, 1983
Overview

- Natural Gas Shales and Fracking
- Dramatic Growth of U.S. Natural Gas Production
- Future Importance of Natural Gas Supply Worldwide
- Technology Improvements and Impact on the Haynesville Shale
- “100 Year” Natural Gas Supply Bolsters Manufacturing Renaissance
Expanding Resource Development has Completely Changed the E&P Business

Good Shales are Prevalent in 17 States (and Western Canada)
Steady U.S. Natural Gas Supply Growth Even with Diminished Rig Count

Annual U.S. Gas Production History Since 2007 (Bcf/d)

Key U.S. Onshore Basins – Gas Production Since 2007 (Bcf/d)

Source: Energy Information Administration
Significant Measures Taken to Prevent Groundwater Contamination

- Surface casing is cemented into place at the uppermost portion of a well for the purpose of protecting the groundwater.

- As the well is drilled deeper, additional casing is installed to isolate the formations.

- Casing and cementing are critical parts of the well construction that not only protect water zones but are also important to successful oil or natural gas production.

Source: API Hydraulic Fracturing 2010.
Fracking a Well is Equipment Intensive for 5-10 Days
The Well Then Produces for 50 Years
Domestic Production of Shale Gas Has Grown Dramatically

Source: Energy Information Administration
Shale Gas Leads Growth in Total Gas Production Through 2040

U.S. Dry Natural Gas Production (Bcf/d)

History 2012 Projections


Production (Bcf/d)

Potential for Optimism in U.S. Natural Gas Price

Historical NYMEX Natural Gas Prices ($ / MMBtu)

Historical NYMEX Natural Gas Prices

Source: Bloomberg and CapIQ as of 4/8/16.
Worldwide Natural Gas Demand Doubles in the Future

Demand by Fuel Type Over Time

- North America is incredibly important for worldwide natural gas
- Shale in North America markedly more attractive than anywhere else and larger impact than anywhere else
- North American gas oversupply needs outlets and new markets

U.S. Production Growth Has Been Unprecedented

Annual U.S. Oil Production History Since 2007 (MMBbls/d)

Key U.S. Onshore Basins – Oil Production Since 2007

Source: Energy Information Administration.
Historical NYMEX Oil Prices ($ / Bbl)

Commodity Pricing Environment

Historical NYMEX Oil Prices ($ / Bbl)

Source: Bloomberg and CapIQ as of 4/8/16.
Offshore Louisiana is Also Critical – More Than 2 MMBoepd from Gulf of Mexico

Gulf of Mexico Deepwater and Shelf Crude Oil Production

Source: Energy Information Administration.
Louisiana Should Continue to Position Itself as a Natural Gas Hub – Upstream, Midstream, and Downstream

- Haynesville is very important to U.S. gas markets
- Typical of the best shales, capital reductions plus reserve per well improvements vastly improving economics

(1) Current net production as of February 2016.
(2) Source: Drilling Info, Henry Hub natural gas pricing.
Advancing To 3,600 lb/ft Completions
Operators Adopting High Proppant Completion Designs

Completion Evolution – Leading Operators

Completion Evolution – All Operators

(1) Represents average estimates.
Case Study: Chesapeake 2,500 lb/ft Nguyen Wells

Nguyen Area Daily Production

Nguyen 7,500’ Production Performance

Nguyen Rate

Nguyen Pressure

Unit Rate

Unit Pressure

7,500’ Rate (mcfd)

Months

Area Layout
Haynesville Operating Improvements
EXCO Resources

D&C Cost / Ft and Average Annual Lateral Length\(^{(1)}\)

- **D&C Cost / ft ($/ft)**: 4,714 to $1,341
- **Lateral Length (ft)**: 3,011 to 7,500

<table>
<thead>
<tr>
<th>Year</th>
<th>D&amp;C Cost ($/ft)</th>
<th>Lateral Length (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>4,714</td>
<td>3,011</td>
</tr>
<tr>
<td>2011</td>
<td>4,675</td>
<td>2,870</td>
</tr>
<tr>
<td>2012</td>
<td>5,090</td>
<td>2,193</td>
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<tr>
<td>2014</td>
<td>6,520</td>
<td>$1,910</td>
</tr>
<tr>
<td>2015</td>
<td>6,841</td>
<td>$1,461</td>
</tr>
<tr>
<td>Current / 2016E</td>
<td>$1,341</td>
<td>7,500</td>
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Drilling Days and Average Annual Lateral Length\(^{(1)}\)

- **Drilling Days**: 59 to 46
- **Lateral Length (ft)**: 4,714 to 7,500

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<tr>
<td>2012</td>
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<td>5,090</td>
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<tr>
<td>2014</td>
<td>47</td>
<td>6,520</td>
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<tr>
<td>2015</td>
<td>43</td>
<td>6,841</td>
</tr>
<tr>
<td>Current / 2016E</td>
<td>46</td>
<td>7,500</td>
</tr>
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Proppant and Average Annual Lateral Length\(^{(1)}\)

- **Proppant (lb/ft)**: 800 to 2,700
- **Lateral Length (ft)**: 4,714 to 7,500

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<th>Lateral Length (ft)</th>
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<td>800</td>
<td>4,714</td>
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<td>Current / 2016E</td>
<td>2,700</td>
<td>7,500</td>
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(1) Source: EXCO Resources Investor Presentation 3/2/2016.
Haynesville Operating Improvements
Chesapeake Energy

**Average Net D&C Cost / Net EUR ($ / Mcf)**

- **Average Net D&C Cost ($ / Mcf)**: $3.16, $2.16, $1.16, $1.00

**Approximate D&C Cost and Cost / Foot**

- **Lateral Length**: 4,500, 5,000, 7,500
- **D&C Cost / ft ($/ft)**: $1,900, $1,500, $1,100
- **D&C Cost ($MM)**: $8.5, $7.5, $8.3

**Average EUR (Bcf)**

- **Lateral Length**: 4,500, 5,000, 7,500
- **Average EUR (Bcf)**: 7.0, 9.3, 14.0

**Drilling Cost / Ft**

- **Quarter**: 2Q14, 3Q14, 4Q14, 1Q15, 2Q15
- **Drilling Cost ($)**: $289, $275, $246, $241, $234

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Natural Gas Infrastructure Broadly Covers the U.S.

U.S. Natural Gas Pipeline Network

Legend:
- = Interstate Pipelines
- = Intrastate Pipelines

Source: Energy Information Administration, Office of Oil & Gas, Natural Gas Division, Gas Transportation Information System
Growth in petrochemical manufacturing increases market opportunities

<table>
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<th>US Projects by Industry</th>
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<tbody>
<tr>
<td>Petrochemicals</td>
<td>60%</td>
</tr>
<tr>
<td>Other organics</td>
<td>6%</td>
</tr>
<tr>
<td>Resins</td>
<td>11%</td>
</tr>
<tr>
<td>Synthetic rubber</td>
<td>1%</td>
</tr>
<tr>
<td>Chlor-alkalis</td>
<td>2%</td>
</tr>
<tr>
<td>Industrial gases</td>
<td>1%</td>
</tr>
<tr>
<td>Fertilizers</td>
<td>19%</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>US Projects by Region</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>US Gulf Coast</td>
<td>72%</td>
</tr>
<tr>
<td>Midwest</td>
<td>13%</td>
</tr>
<tr>
<td>Ohio Valley</td>
<td>9%</td>
</tr>
<tr>
<td>Others</td>
<td>6%</td>
</tr>
</tbody>
</table>

Total investments announced to date $155.3 billion
Source: ACC

<table>
<thead>
<tr>
<th>Capacity Additions of all Chemical Products in US (in thousands of mt/year)</th>
<th></th>
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<tbody>
<tr>
<td></td>
<td>Louisiana</td>
</tr>
<tr>
<td>2015</td>
<td>822</td>
</tr>
<tr>
<td>2016</td>
<td>5,396</td>
</tr>
<tr>
<td>2017</td>
<td>2,174</td>
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<tr>
<td>2018</td>
<td>3,522</td>
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<tr>
<td>2019</td>
<td>8,143</td>
</tr>
<tr>
<td>2020</td>
<td>884</td>
</tr>
<tr>
<td>2021</td>
<td>25</td>
</tr>
</tbody>
</table>

Source: IHS Chemical Week, November 16/23, 2015

Source: Trecora Resources, NYSE Euronext.
U.S. Chemical Industry Global Cost Advantage


Source: ACC Analysis, April 2016
Chemical Investment

264 projects and $164 billion in potential capital investment announced as of April 2016
40% completed or underway, 55% in planning phase
61% is by firms based outside the U.S.

Source: ACC Analysis, April 2016

U.S. Shale Gas

30-year supply that can be profitably produced at $4.00 per million BTUs or less
U.S. chemical industry benefits from lower costs for energy and feedstock

Source: IHS data
Cumulative Announced Chemical Industry Investments from Shale Gas

U.S. Chemical Industry Output from Shale Gas-Related Investments

Billions of 2015 Dollars

- By 2023, additional output from $164 billion in capital investment generates more than $106 billion per year in new chemical industry shipments
- This is an ongoing, permanent upward shift in shipments

Source: ACC Analysis, April 2016
The Build-Out is Underway
(Chemical Industry Construction Spending)

$ Billions, SAAR, 3MMA

Note: Data are presented as a 3 month moving average to smooth month-to-month variations.

Source: Census Bureau
Conclusions

- World and U.S. economies moving to vastly growing natural gas economy
- U.S. shale developments have grown production dramatically
- This growth in production has positively impacted worldwide LNG flows and U.S. manufacturing
- Impacts for Louisiana have been dramatic
  - Growth of Haynesville and vast improvements in economics
  - Growth of manufacturing in Louisiana with natural gas and natural gas liquids as feedstock
  - Near term expected growth, post Macondo, in the Gulf of Mexico