The New Superpower: Emerging Supplies of Gas Liquids from the United States

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President
Washington, DC

CONDENSATE & NAPHTHA FORUM
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A Brave New World For Gas Liquids:
Implications for Refining & Petrochemical Markets
The North American Petroleum Renaissance

Take Aways

• Shale Gas Revolution and Its application to liquid plays is generating sustained and long-term large scale additions to NGL output.

• Capital requirements for gas processing are massive, persistent flaring a problem.

• Like crude oil distribution, output of NGLs is requiring major capital requirements for transportation infrastructure. Fixing chokepoints critical.

• Outlook for frac spreads remains high and markets are expanding

• While some modest ethane oversupply is possible before 2015, U.S. petrochemical industry will absorb the output through new plants.

• Propane and LPG exports will rise, and “spiking” opportunities will emerge for LNG exports with some diversion of propane into the LNG stream.

• U.S. is fast becoming the low cost petrochemical export platform. Wild card risk remains government policy.
North American Production Potential

Note: The oil supply bars for 2035 represent the range of potential supply from each of the individual supply sources and types considered in this study. The specific factors that may constrain or enable development and production can be different for each supply type, but include such factors as whether access is enabled, infrastructure is developed, appropriate technology research and development is sustained, an appropriate regulatory framework is in place, and environmental performance is maintained.

Source: Historical data from Energy Information Administration and National Energy Board of Canada.
Total Canadian Oil Production (NEB Reference Case)

## Cost of Oil Sands Production

### Estimated Initial Capital Expenditure (CAPEX) and Threshold\(^{(a)}\) Prices for New Oil Sands Projects

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Mining, Extraction and Upgrading</td>
<td>$85,000-$105,000</td>
<td>$85-$95</td>
</tr>
<tr>
<td>Mining and Extraction Only (No upgrading)</td>
<td>$60,000-$75,000</td>
<td>$65-$75</td>
</tr>
<tr>
<td>Steam-assisted Gravity Drainage (SAGD)/Cyclic Steam Stimulation (CSS)</td>
<td>$25,000-$40,000</td>
<td>$50-$60</td>
</tr>
</tbody>
</table>

\(^{(a)}\) Includes a realistic after-tax rate of return, commonly in the order of 10 to 15%.

Projected Imports of LNG vs. Actual
(or why forecasters should have humility)

Prices at $2.50 to $2.80 in Feb 2012

Source: EIA data and forecasts
Disposition of US Natural Gas

Source: EIA data, Navigant data, EPRINC calculations
U.S. Natural Gas Liquids Field Production

Source: EIA Data
U.S. natural gas production, 1990-2035 (trillion cubic feet)

Source: EIA AEO 2012
Oil and Gas Permits

Source: HPDI Feb 13, 2012
Rig Count and Permits

Source: Photo Baker Hughes Interactive Rig Count Jan 25, 2012
Rich vs. Dry Gas Additions, 2010-2011

Source: ITG IR, raw data provided by didesktop (HPDI)
Estimated Ultimate Recovery

Source: Brigham Exploration via World Oil
Technology Matters

• Overtime companies in the Bakken have improved their techniques

• Only a few years ago frac stages were minimal, but now they are 30 plus with some trying to go as high as 60

• Typically, more fracturing means more production, but this also increases cost, usually more than paid for by the increased production

• Horizontal laterals now common in the Bakken and across the country were once around 4,000 ft and are now as long as 10-15,000 ft

• “…40 fracture stimulations are now pushing ultimate recovery figures to well over 600,000 and 700,000 barrels of oil.” (Oil Patch Hotline)
Unconventional Liquids 2011 to 2017

Raymond James

Eagle Ford Liquid Daily Average
Bakken/Three Forks Liquid Daily Average
Niobrara/Codell Liquids Daily Average
Permian Basin Liquids Daily Average

Note:
Sustainable rates of NA upstream Liquids Growth now Likely at 500 kbbls/yr.

Source: EPRINC, Building Blocks of the NA Petroleum Renaissance
Bakken Production in Only Montanta
US Net Imports of Liquified Petroleum Gases

Source: EIA
Thermoplastic Exports and Oil-to-Gas Ratio

Source: American Chemistry Council
Ethane Prices Track Gas Prices

Ethane Prices (left) vs Natural Gas Prices (right)
U.S. Propane and Gasoline Prices

Mont Belvieu, TX Propane Spot Price FOB (Dollars per Gallon)

Los Angeles Reformulated RBOB Regular Gasoline Spot Price (Dollars per Gallon)

Source: EIA Data
Natural Gas Flaring

Source: NDPA
So, why so much flaring? Regulatory Issue?

1. Feasibility and economic viability of immediately getting gas to market. Most of these wells will in time will be hooked up to gas processing facilities; however, there are some wells in North Dakota that are decades old and so far from any other existing well or facility that it may never be feasible to capture the gas from that single well.

2. Severe weather limitations in North Dakota, housing shortages, manpower

3. Size and Maturity of the Play. New play with rapid development (partially because of leasing requirements) and spread across over 15,000 sq. miles continually seeing better well completion and higher production rates

4. Valuable associated natural gas that is high in NGLs, but low in pressure, must be processed and separated to remove the different components in the NGL stream. Much higher value than current Henry Hub prices

5. Over $3 billion is being invested by the industry for gathering and processing in the next few years. Significant gathering and processing growth has taken place over the past several years, but has simply been unable to keep up with such strong production growth...lag in gathering, compression, and processing infrastructure...older facilities were not built to handle current volumes
Process Flow Diagram for Tracking NGLs

The EIA tabulates the amount of each NGL component in the NGL mix as it exits the gas processing plant.

There is no public information about the volume of individual NGLs exiting the fractionators.

- Ethane or EP Mix
- Propane
- N-Butane
- i-Butane
- Natural Gasoline
- Mixed NGLs

Mixed NGLs

Standalone or Centralized Full Fractionator

NGL Storage

- Ethane
- Propane
- Butane Plus

Refinery

NGL Products

Processing Plant + Partial Fractionation
NGLs and the Value of New Cryogenic Plants

<table>
<thead>
<tr>
<th>Typical Bakken Analysis</th>
<th>Refrigeration</th>
<th>Recovered</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mol %</td>
<td>GPM</td>
<td>Rec %</td>
</tr>
<tr>
<td>N2</td>
<td>4.626</td>
<td></td>
<td>0.00%</td>
</tr>
<tr>
<td>CO2</td>
<td>0.858</td>
<td></td>
<td>5.00%</td>
</tr>
<tr>
<td>C1</td>
<td>51.246</td>
<td></td>
<td>70.00%</td>
</tr>
<tr>
<td>C2</td>
<td>20.374</td>
<td></td>
<td>80.00%</td>
</tr>
<tr>
<td>C3</td>
<td>13.407</td>
<td></td>
<td>90.00%</td>
</tr>
<tr>
<td>i-C4</td>
<td>1.443</td>
<td></td>
<td>100.00%</td>
</tr>
<tr>
<td>n-C4</td>
<td>5.335</td>
<td></td>
<td>100.00%</td>
</tr>
<tr>
<td>i-C5</td>
<td>0.909</td>
<td></td>
<td>100.00%</td>
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<tr>
<td>n-C5</td>
<td>1.403</td>
<td></td>
<td>100.00%</td>
</tr>
<tr>
<td>C6+</td>
<td>0.399</td>
<td>0.173</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>100.000</th>
<th>12.304</th>
<th>5.76</th>
<th>Refrig. Plant</th>
<th>11.18</th>
<th>Cryogenic Plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value of the Residue Sale per Mcf</td>
<td>$ 3.124</td>
<td></td>
<td></td>
<td>Value of the Liquid Sale per Mcf</td>
<td>$ 8.030</td>
<td>$ 11.644</td>
</tr>
<tr>
<td>Value at the Wellhead per Mcf</td>
<td>$ 11.155</td>
<td></td>
<td></td>
<td></td>
<td>$ 13.458</td>
<td></td>
</tr>
</tbody>
</table>

Pricing is based on 100% of the value at the sales point i.e. tailgate of the Plant. No costs assumed for gathering and processing.

Pricing is based on average prices paid at two different plants in the Bakken area averaged August 2011 - November 2011. Difference shown is the recovery in a full Cryogenic vs a Refrigeration Plant.

Ethane recoiled in a refrigeration plant is shown as getting a gas (residue value).
Natural Gas Liquid Content

The primary rise in production of NGLs has been in ethane and this is set to continue

- Ethane is cracked and used to make ethylene which is used as a petrochemical feedstock primarily to make plastics → this will likely be used here in the U.S. or exported

We will likely have incremental growth in propane, butane, and natural gasoline/pentanes+, but they probably won't be game changing.

- **Ethane**: petrochemical building block and is used to produce ethylene, a common feedstock in plastics manufacturing
- **Propane**: petrochemical feedstock for making ethylene and propylene, although used primarily as a fuel
- **Normal butane**: petrochemical feedstock and a refining blend stock for gasoline
- **Iso-butane**: refining feedstock and a component of gasoline octane blends

Source: EIA
NGLs, Infrastructure, and Ethylene Plants

### Rich Gas Shales
- **Avalon/Bone Springs**: 4.0 to 5.0
- **Bakken**: 6.0 to 12.0
- **Barnett**: 2.5 to 3.5
- **Cana-Woodford**: 4.0 to 6.0
- **Eagle Ford**: 4.0 to 9.0
- **Granite Wash**: 4.0 to 6.0
- **Green River**: 3.0 to 5.0
- **Niobrara**: 4.0 to 9.0
- **PiceanceUinta**: 2.5 to 3.5
- **Montney**: 3.0 to 4.5
- **Marcellus–Utica**: 4.0 to 9.0

1. GPM = gallons NGLs per mcf
2. Oil Shale Plays
3. Oil and Gas Shale Play

Source: Veresen, Presentation Bakken Product Markets and Take-Away Denver Jan 31-Feb 1 2012
Near Term Constraints

Surging NGL production has brought about major pipeline bottlenecks (although new transportation infrastructure projects are underway)

1. Conway to Mt. Belvieu Corridor
2. Rocky Mountain to Mt Belvieu or Conway
3. Bakken Shale to Conway
4. West Texas to Mt. Belvieu
5. S. Texas to Mt. Belvieu

Needed: More ethane distribution capacity to Gulf Coast + propane plus distribution capacity is also required to NE and Midwest markets.
Explaining the Frac Spread

A heavy drop in natural gas prices combined with stagnant natural gas liquid (NGL) prices helped to improve the frac spread margins for butane and C5+, along with Conway ethane from December 1 to January 17, 2012.

While Conway ethane had the most improved frac spread margin of any NGL from the end of 2011 and the start of 2012 at 33%, it has flirted with becoming unprofitable and being rejected at the hub. Once an NGL hits a margin under 6¢ per gallon (/gal), it is by-and-large unprofitable because of the added expenses necessary to do business and produce it.

Although Mont Belvieu ethane’s margin fell 14% in the six-week period of this issue’s frac spread, it is much more profitable than its Conway counterpart. The 38¢/gal-differential between the two hubs is due to the strong market for ethane in the Gulf Coast because of large ethylene-cracking capacity. By comparison, the Conway market for ethane is nearly non-existent and there is limited transportation capacity out of the region, which is causing a bottleneck at the hub.

Total NGLs Extracted From Gas Processing

Source: EIA, Baker Hughes, and En*Vantage
NGLs Extracted from the Gas Stream

Source: EIA and EnVantage
Petrochemical Cost Curve, By Country 2010

Cash Costs
($/Pound)

High

Low

Cumulative Supply Quantity (Billion Pounds)

Source: American Chemistry Council
North American NGL, LPG, HVL Pipelines

NGL, LPG, HVL Pipelines and Nat Gas Processing Plants
North American Natural Gas Pipelines

### NGL Value in $/MMBtu

**CURRENT FRAC SPREAD (CENTS/GAL)**

<table>
<thead>
<tr>
<th>NGL Value in $/MMBtu</th>
<th>Conway Change from Last Week</th>
<th>Mont Belvieu</th>
<th>Last Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethane</td>
<td>1.54 -12.01%</td>
<td>3.6</td>
<td>-17.27%</td>
</tr>
<tr>
<td>Propane</td>
<td>3.37 -25.11%</td>
<td>4.35</td>
<td>-13.43%</td>
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<tr>
<td>Normal Butane</td>
<td>1.9 2.55%</td>
<td>2.18</td>
<td>2.66%</td>
</tr>
<tr>
<td>Isobutane</td>
<td>1.14 -16.93%</td>
<td>1.32</td>
<td>-11.01%</td>
</tr>
<tr>
<td>Pentane+</td>
<td>2.73 2.85%</td>
<td>3.01</td>
<td>5.31%</td>
</tr>
<tr>
<td><strong>Total bbl. value in $/MMbtu</strong></td>
<td><strong>10.68 -11.95%</strong></td>
<td><strong>14.47</strong></td>
<td><strong>-8.72%</strong></td>
</tr>
<tr>
<td><strong>Margin</strong></td>
<td><strong>8.18 -5.20%</strong></td>
<td><strong>11.98</strong></td>
<td><strong>-3.95%</strong></td>
</tr>
</tbody>
</table>

Conway gas based on NGPL Midcontinent zone, Mont Belvieu based on Houston Ship Channel.

The Frac Spread

The frac spread is the value one gets for the sale of natural gas liquids minus the cost of natural gas used to extract the natural gas liquids.

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<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Ethane</td>
<td>27.98</td>
<td>65.45</td>
<td></td>
<td></td>
<td>-13.68%</td>
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<tr>
<td>Shrink</td>
<td>16.58</td>
<td>16.51</td>
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<tr>
<td>Margin</td>
<td>11.41</td>
<td>48.94</td>
<td>-10.18%</td>
<td></td>
<td>-9.92%</td>
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<tr>
<td>Propane</td>
<td>96.98</td>
<td>125.2</td>
<td></td>
<td></td>
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<tr>
<td>Shrink</td>
<td>22.9</td>
<td>22.81</td>
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<tr>
<td>Margin</td>
<td>74.08</td>
<td>102.39</td>
<td>-23.97%</td>
<td></td>
<td>-10.18%</td>
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<tr>
<td>Normal Butane</td>
<td>175.83</td>
<td>202.18</td>
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<tr>
<td>Shrink</td>
<td>25.93</td>
<td>25.82</td>
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<tr>
<td>Margin</td>
<td>149.91</td>
<td>176.36</td>
<td>10.91%</td>
<td></td>
<td>8.93%</td>
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<tr>
<td>Isobutane</td>
<td>183.5</td>
<td>212.85</td>
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<tr>
<td>Shrink</td>
<td>24.9</td>
<td>24.8</td>
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</tr>
<tr>
<td>Margin</td>
<td>158.6</td>
<td>188.05</td>
<td>-14.75%</td>
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<td>-8.50%</td>
</tr>
<tr>
<td>Pentane+</td>
<td>211.9</td>
<td>233.55</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shrink</td>
<td>27.73</td>
<td>27.61</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Margin</td>
<td>184.18</td>
<td>205.94</td>
<td>10.14%</td>
<td></td>
<td>11.75%</td>
</tr>
<tr>
<td>NGL $/bbl.</td>
<td>44.64</td>
<td>57.12</td>
<td>-9.84%</td>
<td></td>
<td>-6.62%</td>
</tr>
<tr>
<td>Shrink</td>
<td>9.13</td>
<td>9.1</td>
<td></td>
<td></td>
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<tr>
<td>Margin</td>
<td>35.5</td>
<td>48.02</td>
<td>-3.32%</td>
<td></td>
<td>-1.63%</td>
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<tr>
<td>Gas ($/MMBtu)</td>
<td>2.5</td>
<td>2.49</td>
<td>-28.57%</td>
<td></td>
<td>-26.33%</td>
</tr>
<tr>
<td>Gross Bbl Margin (in cents/gal)</td>
<td>80.68</td>
<td>111.28</td>
<td>-4.75%</td>
<td></td>
<td>-2.44%</td>
</tr>
</tbody>
</table>

Explaining the Frac Spread

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LNG Btu Requirements
LNG Energy Content

• Japan has among the world’s highest requirements for LNG energy content
• The US shale boom – both liquid and gas plays – is providing ever growing supplies of ethane and propane
  • Key ‘spiking’ ingredients are available in quantity
  • At depressed prices
    • Ethane supplies attracting new petrochemical plant projects
  • Widely available in the Gulf Coast
• Ethane supply growth has outpaced all other NGLs (natural gas liquids)
NGL Production Outlook to 2020

Source: EIA Data, EPRINC forecast. Assumes ethane continues to incrementally increase its share of the NGL pool.
Some Final Observations

• Over the long-term, we are likely to have a balanced NGL market as long as the gas-to-crude ratio stays low.

• Petrochemical industry poised to crack more ethane.

• Export markets and dehydrogenation will be key in keeping the C3+ part of the NGL barrel balanced.
  
• NGL imbalances are possible, but unlikely to be chronic. Major risk is a spike in natural gas prices (but this is unlikely)

• Lots of projects underway, so risk of NGL infrastructure capacity (y-grade pipes and fractionators) could be overbuilt in the next 5 years

• Government remains a risk
Regulators’ Hiring Boom

Federal regulatory agencies are ramping up staff and churning out new rules as the private sector struggles.

Cumulative change since March 2010

- Federal regulatory agency jobs: 5.2%
- All federal government jobs (ex census temps): 2.1%
- Private-sector jobs: 1.4%


*Includes roughly 20 major federal regulatory agencies, such as the EPA, FCC, FDA, etc. Does not include TSA or Consumer Financial Protection Bureau.