Assessing the Impact of the Changing Crude Oil Landscape in North America

Baker & O’Brien, Inc.

November 5, 2013
Discussion Topics

- Introduction
- U.S. and Canada Sulfur Production Trends and Overview
- Crude Oil / Refining Evaluation Framework
  - U.S Refining Inputs of Sulfur
  - U.S. Heavy Oil Conversion Activity (Coking)
  - Fuel Regulatory Impacts
- Outlook
Introducctio

Baker & O’Brien: Independent Energy Consultants

Overview
- Independently owned and managed
- Technical and commercial expertise
- Active over full life cycle of assets: new project development -> business support -> commercial disputes

Consulting Staff
- Chemical, mechanical, and electrical engineers
- Consultants average over 25 years industry experience
- Experienced problem solvers
U.S. and Canada Sulfur Production Trending Down Amid Global Growth

- U.S. and Canada declines both driven by reduced sour gas processing

**U.S., Canada, and Global Sulfur Production Trends, million tonnes/year**

Sources: U.S. Geological Survey, (USGS), Natural Resources Canada, Baker & O’Brien analysis
U.S. is net short sulfur; primary import sources are Canada (80+% and Mexico (12%). Refineries account for 88% of produced supply; gas plants only account for 12%.

**U.S. Sulfur Balance – 2012 (000 tonnes)**

- **Exports**: 1,850
- **Consumption**: 9,490
- **Imports**: 2,930
- **Refineries**: 7,320
- **Gas Plants**: 1,040

**Supply Sources**

**Disposition**

Sources: USGS, Baker & O’Brien analysis
Trends & Overview

- Sulfur from gas processing has trended lower with declining conventional production
- Refinery sulfur production has been generally flat

U.S. Sulfur Production, 000 tonnes per year

Source: USGS
• Sour natural gas and oil sands upgrading are primary sources
• Sulfur production greatly exceeds domestic needs; excess sulfur is exported

Canada Sulfur Balance Overview

Canada Sulfur Balance – 2012 (000 tonnes)

Supply Sources

- Refineries 460
- Oil Sands Upgraders / Heavy Refineries 2,200
- Gas Plants 2,900

Recent Trends

Disposition

- Exports 4,650
- Consumption 850

Sources: Natural Resources Canada, Canadian Association of Petroleum Producers, PentaSul, Baker & O’Brien analysis
Canada Sulfur Production Decline Driven By Declining Gas Production

- Sulfur produced from gas processing has declined by about 45%
- Sulfur from heavy oil upgrading has continued to grow
- Total Canada gas production has declined 17% in the past 5 years (2007-2012); Alberta gas production has declined 24% over the same period

Sources: Natural Resources Canada, CAPP, PentaSul, Baker & O’Brien analysis
• U.S. refining accounts for over 50% of total production, followed by Canadian sour gas (20%) and oil sands upgraders (15%)

U.S. and Canada Sulfur Production Summary, 000 tonnes

Sources: Natural Resources Canada, CAPP, PentaSul, EIA, USGS, Baker & O’Brien analysis
PADD 3 accounts for over 60% of total sulfur production, driven by refinery processing capacity and gas production sources.

**U.S. Sulfur Production by PADD in Q1 2013, 000 tonnes**

<table>
<thead>
<tr>
<th>PADD 3</th>
<th>PADD 2</th>
<th>PADD 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,120</td>
<td>263</td>
<td>4</td>
</tr>
</tbody>
</table>

**Legend**
- Sulfur from natural gas processing, 000 tonnes
- Sulfur from petroleum refining, 000 tonnes

Sources: EIA, USGS, Baker & O’Brien analysis
### U.S. Refining System Sulfur Balance - 2012

<table>
<thead>
<tr>
<th>Inputs</th>
<th>000 tonnes</th>
<th>% of Total Input</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude Oil</td>
<td>10,856</td>
<td>98%</td>
</tr>
<tr>
<td>Feedstocks</td>
<td>246</td>
<td>2%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>11,102</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Outputs</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Elemental Sulfur</td>
<td>7,320</td>
<td>66%</td>
</tr>
<tr>
<td>Petcoke</td>
<td>2,220</td>
<td>20%</td>
</tr>
<tr>
<td>Asphalt</td>
<td>794</td>
<td>7%</td>
</tr>
<tr>
<td>Other</td>
<td>372</td>
<td>3%</td>
</tr>
<tr>
<td>Residual Fuel Oils</td>
<td>322</td>
<td>3%</td>
</tr>
<tr>
<td>Light Refined Products</td>
<td>75</td>
<td>1%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>11,102</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

- Two-thirds of sulfur input to the U.S. refining system is recovered as elemental sulfur.
- Other large sulfur “sinks” include petcoke (20% of inputs) and asphalt (7%).
- Gasoline, diesel, heating oil, jet fuel account for less than 1%; jet fuel is about 60% of the total.

**Sources:** PRISM refinery database system, Baker & O’Brien analysis
Refinery sulfur production is a function of crude slate and configuration

- Large coking refineries produce sulfur volumes that are 1-2 orders of magnitude higher than simpler refineries
- For most refineries, recovered sulfur will likely be in the range of 60-70% of input sulfur, unless there are large yields of asphalt and residual fuel oil.

### Refinery Sulfur Balances Dominated by Heavy Sour Coking Refineries

<table>
<thead>
<tr>
<th>Refinery Type</th>
<th>Refinery A</th>
<th>Refinery B</th>
<th>Refinery C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elemental Sulfur, 000 tonnes/year</td>
<td>327</td>
<td>21</td>
<td>4</td>
</tr>
<tr>
<td>Fraction of Total U.S.</td>
<td>4.5%</td>
<td>0.3%</td>
<td>&lt; 0.1%</td>
</tr>
<tr>
<td><strong>Sulfur Disposition, % of input</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elemental Sulfur</td>
<td>64%</td>
<td>38%</td>
<td>70%</td>
</tr>
<tr>
<td>Petcoke, Asphalt, Fuel Oil</td>
<td>36%</td>
<td>62%</td>
<td>21%</td>
</tr>
<tr>
<td>Light Transportation Fuels</td>
<td>0.3%</td>
<td>0.6%</td>
<td>8.8%</td>
</tr>
</tbody>
</table>

Sources: PRISM refinery database system, Baker & O’Brien analysis
A. Total Inputs of Sulfur
   - Refinery run rates
     - Global supply/demand
     - U.S. competitive advantage
   - Crude slate sulfur levels
     - U.S. growth of light/sweet
     - Canadian oil sands growth
     - Heavy/Sour imports

B. Conversion of Bottom of Barrel
   - Coker; refinery expansion projects
   - Pet coke gasification

C. Sulfur Regulatory Activity
   - EPA Tier 3 (gasoline)
   - Northeast States Heating Oil
A. Inputs

Crude Oil Dynamics in Americas Impacting the Sulfur Supply Equation

• Country crude oil production profiles will influence the sulfur production outlook, among other factors

  – Growing: U.S., Canada, Colombia, Brazil
  – Flat-to-Declining: Mexico, Venezuela, Ecuador
Changes in the U.S. and Canada Most Impactful

Petroleum Production, MMB/D

Growing Regions
- Colombia
- Brazil
- Canada
- United States

Flat or Declining Regions
- Ecuador
- Venezuela
- Mexico

Source: EIA
A. Inputs

Sulfur Inputs to U.S. Refineries Rebounding to 2008 Levels

- Generally flat crude slate sulfur content within range of 1.4-1.5 wt%

- Generally flat crude oil charge rates around 15 million B/D

Sources: EIA, Baker & O’Brien analysis
PADD Crude Slate Sulfur Trends Have Been Mixed

- Overall U.S. sulfur content has been relatively flat and slightly increasing
- PADD 3 sulfur content has been declining, but PADDs 2, 4, and 5 have been increasing

Sources: EIA, Baker & O’Brien analysis
The top five crude oil source countries – Canada, U.S., Venezuela, Saudi Arabia, and Mexico – account for 85% of total sulfur inputs.

Future projections a “mixed” bag: increased imports of heavy, sour diluted bitumen from Canada, offset to some degree by low-sulfur tight oil production growth.

**Sources of Sulfur Inputs (Q1 2013) and Expected Trends**

- **Canada**: Increasing heavy, sour grades.
- **USA**: Increasing sweet (Bakken, Eagle Ford, Permian).
- **Venezuela**: Flat to declining production.
- **Saudi Arabia**: Flat to declining imports; lighter grades displaced.
- **Kuwait**: Declining imports.
- **Mexico**: Declining imports?
- **Ecuador**: Flat to declining production.
- **Iraq**: Declining imports?
- **All Others**: Increasing sour (GOM, Permian), but less so than sweet grades.

Sources: EIA, PRISM refinery database system, Baker & O’Brien analysis.

U.S. Crude Oil Production Trends

Source: EIA
A. Inputs

Outlook for U.S. and Canada Crude Oil Production

- U.S. production may exceed 10 MMB/D early next decade before peak/plateau
- Combined with Canada, incremental growth of over 5 MMB/D expected vs. 2013

**U.S. and Canada Supply Outlook**

Note: Canadian crude oil supply includes diluent which is imported for blending of DilBit (diluent/bitumen blend).

Sources: Canadian Association of Petroleum Producers, (CAPP), Baker & O’Brien analysis
Drastically Changing North American Crude Mix

- Over the near term (to 2015), the U.S. will see more light-sweet grades and heavy-sour grades, displacing medium grades.
- After 2015, light supplies grow further as heavy oil runs plateau.
- Sulfur input into the U.S. refining system increases.

### Sulfur Input Changes, 000 tonnes/year

<table>
<thead>
<tr>
<th>Changes vs. 2012</th>
<th>2015</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light-Sweet Grades</td>
<td>96</td>
<td>133</td>
</tr>
<tr>
<td>Medium Grades</td>
<td>(1,286)</td>
<td>(1,930)</td>
</tr>
<tr>
<td>Heavy-Sour Grades</td>
<td>1,560</td>
<td>1,949</td>
</tr>
<tr>
<td>Difference</td>
<td>370</td>
<td>153</td>
</tr>
</tbody>
</table>

Source: Baker & O'Brien analysis
### Refiners Shifting Gears to Process More Light-Sweet

- **Flint Hills (Corpus Christi) and Valero (Corpus Christi, Houston)** are early movers

<table>
<thead>
<tr>
<th>Company-Location</th>
<th>Investment</th>
<th>Timing</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flint Hills-Corpus Christi</td>
<td>$250 MM</td>
<td>2015</td>
<td>Sat gas plant; new and modified tankage; only modest increase to existing capacity</td>
</tr>
<tr>
<td>Valero-Corpus Christi</td>
<td>$240 MM</td>
<td>Late 2015</td>
<td>70 MB/D topping unit</td>
</tr>
<tr>
<td>Valero-Houston</td>
<td>$290 MM</td>
<td>Late 2015</td>
<td>90 MB/D topping unit</td>
</tr>
<tr>
<td>Valero-McKee</td>
<td></td>
<td>Mid 2015</td>
<td>25 MB/D expansion</td>
</tr>
<tr>
<td>Valero-Meraux, Port Arthur</td>
<td></td>
<td></td>
<td>Evaluating low-cost projects to unlock light crude oil capacity</td>
</tr>
<tr>
<td>Lyondell-Houston</td>
<td></td>
<td></td>
<td>Minor modifications during Q1 2013 turnaround to increase light crude oil capacity</td>
</tr>
<tr>
<td>Marathon – Texas City</td>
<td></td>
<td></td>
<td>Will discuss modifications at investor day meeting in December</td>
</tr>
<tr>
<td>Phillips 66-Lake Charles, Sweeny</td>
<td></td>
<td></td>
<td>Making modifications to enable processing of more advantaged crude oil</td>
</tr>
</tbody>
</table>
Record Coking Margins and Anticipated Oil Sands Growth Drove Massive Investments in Delayed Cokers

• Over $30 billion has been invested in U.S. coker-related refinery expansions over the past 5-7 years

**Historical Perspectives on Light-Heavy Spreads and Coking Margins**

Historically, high margins triggered a "super-cycle" in conversion and expansion investments.

Sources: Platts, Baker & O'Brien Analysis

---

B. Conversion
However, Limited Availability of Heavy Oil Has Resulted in Poor Coking Margins

- Declining imports from Mexico, Venezuela have contributed to under-utilized cokers
- Growth in Canada, Colombia, and Brazil have helped to offset decline somewhat, but have not been enough to fill current and projected coking capacity

**U.S. Crude Oil Imports from Countries with Heavy Oil, MB/D**

Source: EIA
B. Conversion

Refiners Anticipated Higher Sulfur Recovery Needs

- Deep conversion (coking) projects were developed in anticipation of increased heavy oil production in Canada and, generally, to increase competitiveness
- These projects required extensive increases to sulfur removal capacity
- However, sulfur production has been relatively flat and utilization of SRU capacity has trended lower

**U.S. Refinery Sulfur Capacity & Production**

Sources: EIA, Baker & O’Brien analysis
B. Conversion

Sulfur Production to Grow Further After Last of Large Expansion Projects are in Operation

- Sulfur production should increase by 300,000-400,000 tonnes/yr (4-5% of total U.S.) once design rates are achieved at Motiva Port Arthur and BP Whiting.

**U.S. Refinery Sulfur Production, 000 tonnes/year**
*(Top 65 refineries shown, accounting for 95% of total sulfur)*

Sources: PRISM refinery database system, Baker & O’Brien analysis
Asphalt and fuel oil production have declined while petcoke production (coking) is only slightly above levels from 8 years ago. Availability of heavy crude oil has limited coker throughputs.
C. Regulatory

Regulatory Factors Not Likely to “Move the Needle” on Total Sulfur Production in Medium Term

- **Light Products**
  - Reduced sulfur in home heating oil (driven primarily by northeast states)
  - Reduced sulfur in gasoline (EPA Tier 3)
  - Although highly impactful to refinery capital requirements, the total sulfur contained in all light refined products (including jet fuel and high-sulfur exports) is less than 1% of total supply

- **Reduced Sulfur in Bunker Fuels**
  - By 2015, sulfur content of marine fuel oil consumed in certain emission control areas must be reduced to 0.1% from current 1%
  - By 2020 aggressive reductions in bunker fuel sulfur levels are being sought: targeting 0.5% vs. 3.5% (current sulfur levels), subject to a feasibility review to be completed no later than 2018.
  - Sulfur in global bunker volumes (3.5% down to 0.5%) estimated at 8 million tonnes/yr or ~11% of global sulfur production
  - Potential to be highly impactful to global supply-demand; however, seems likely that timeline will be extended
A. Total Inputs of Sulfur
   – Refinery run rates to get marginally higher with Motiva Port Arthur at full steam, expansion “creep” projects, and small new-builds
   – Crude slate sulfur levels to go up in near term and decline slightly in outer years

B. Conversion of Bottom of Barrel
   – The last two mega-projects will result in sulfur production increases in near-term, but that will be the end of the investment cycle for a while

C. Sulfur Regulatory Activity
   – Not impactful over medium term
Dynamic Shifts in Refining, but…

Relatively Static Total Sulfur Output

- U.S. refinery and Canadian upgrader sulfur production should trend higher with increased heavy oil processing and reduced imports of lower-sulfur grades
- Natural gas sulfur production expected to continue to trend lower
- Total sulfur production likely to continue slow decline

**U.S. and Canada Sulfur Production Outlook, 000 tonnes**

- **Upgrading-Can**
- **Gas Proc-Can**
- **Refining-Can**
- **Gas Proc-US**
- **Refining-US**

Source: Baker & O’Brien analysis
Baker & O’Brien: Independent Energy Consultants

Dallas
12001 N. Central Expressway,
Suite 1200
Dallas, TX 75243
Phone: 1-214-368-7626
Fax: 1-214-368-0190

Houston
1333 West Loop South
Suite 1350
Houston, TX 77027
Phone: 1-832-358-1453
Fax: 1-832-358-1498

London
146 Fleet Street
London EC4A 2BU
Phone: 44-20-7373-0925

Celebrating a Tradition of Service

www.bakerobrien.com