North American Refining
Changing Crude Supply & Qualities

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COQA

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Today’s Speaker

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LSU Chemical Engineer
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Strategic planning, FMV, ventures
Directs firm activities
TM&C Overview

International consulting practice since 1971
Downstream focus; refinery/chemical engineers
Industry and financial clients
  • Strategic Studies
  • FMV Assessments & Venture Analyses
  • National Policy Studies

Publish various outlook and multi-client subscription reports
  • World Crude Outlooks
  • North American Crude & Condensate Outlook
  • Crude and Refined Products Outlook
  • Refinery Construction Outlook
  • Special Studies
Today’s Agenda

Major Developments in N.A. Crude Supply

- NACCO Projections to 2022
  - U.S. by PADD & Grade
  - Canada
- Changing Crude Flows/Sources
- Impact on Foreign Imports
- Quality Changes
- Crude Exports?

Refinery Yield Impacts

Export Issues

Some Final Thoughts
North American Crude & Condensate Outlook

- Regional forecasts in new TO and conventional areas
- Evaluation of refinery capabilities on a plant-by-plant basis
- Analysis of planned/required logistics
- Evaluate challenges and opportunities for producers, midstream companies and refiners
- Forecast pricing implications
- Initial publications – June & October 2012
- 2013 NACCO released in June
Major N.A. Crude Regions
Approximate Current Production Levels

- Oil Sands Basins: 3.3 MMBPD
- Williston Basin: 900 MBPD
- Niobrara: 160 MBPD
- Oklahoma/Kansas: 450 MBPD
- Permian Basin: 1.3 MMBPD
- Eagle Ford: 900 MBPD
- Gulf of Mexico: 1.3 MMBPD
- California: 600 MBPD
- Offshore E. Canada: 250 MBPD
- Alaska: 500 MBPD
Crude Production Increases – U.S. 2008 to 1H2013

Source: EIA
Projected Production Volumes by 2022

U.S.
- Low Case 9.5 MMBPD
- High Case 12.0 MMBPD

Canada
- 5.5 MMBPD

Forecast Assumptions
- Absolute crude prices (Brent) remain in $80 to $120 range
- Key limitations (manpower, materials, regulatory, financial, etc.)
- Build out of crude transportation assets is critical
- Limited production from some high potential prospects
- High case requires significant crude exports
# Crude Oil Grades

## Crude Oil Categories

<table>
<thead>
<tr>
<th></th>
<th>Gravity</th>
<th>Sulfur Wt. %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condensate</td>
<td>≥ 55.0</td>
<td>All</td>
</tr>
<tr>
<td>Super Light</td>
<td>42.0 – 55.0</td>
<td>All</td>
</tr>
<tr>
<td>Light Sweet</td>
<td>31.0 – 41.9</td>
<td>≤ 0.99</td>
</tr>
<tr>
<td>Light Sour</td>
<td>31.0 – 41.9</td>
<td>≥ 1.00</td>
</tr>
<tr>
<td>Medium</td>
<td>24.1 – 30.9</td>
<td>All</td>
</tr>
<tr>
<td>Heavy</td>
<td>≤ 24.0</td>
<td>All</td>
</tr>
</tbody>
</table>
Change in Crude Production by Grade
2012 to 2022

MBPD

Condensate/ Light Sweet
Light Sour
Medium
Heavy

US Low  US High  Canada
U.S. Crude Supply/Demand

MMBPD

- Low
- High
- Refinery Runs

N.A. Crude Flows

U.S.
- Bakken will flow primarily to the East Coast and the PNW
  - Movements to PADD III will be largely eliminated by 2014
- Eagle Ford will generally be consumed in PADD III with some volumes moving to Atlantic Coast refineries (both U.S. and Canada)
  - Exports required in High Production Case

Canadian Production
- PADD II heavy crude expansions will soak up most of the addnl. hvy production in the short term
- Significant volumes will not reach the USGC until 2016
Other Foreign Imports

- Lt. Sweets backed out of PADD III by the end of 2013/early 2014
- Most Lt. Sours replaced in PADD III by mid-decade
- Role of foreign Medium grades is declining; some remain as “structural imports” – Motiva/USWC
- High Case has most Medium grades out of PADD III by 2016
Changing U.S. Crude Oil Sources

<table>
<thead>
<tr>
<th>Year</th>
<th>Domestic</th>
<th>Canada</th>
<th>Waterborne</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>35%</td>
<td>10%</td>
<td>54%</td>
<td>100%</td>
</tr>
<tr>
<td>2008</td>
<td>34%</td>
<td>13%</td>
<td>53%</td>
<td>100%</td>
</tr>
<tr>
<td>2012</td>
<td>43%</td>
<td>16%</td>
<td>41%</td>
<td>100%</td>
</tr>
<tr>
<td>2022</td>
<td>61%</td>
<td>66%</td>
<td>25%</td>
<td>100%</td>
</tr>
<tr>
<td>2022 High</td>
<td>25%</td>
<td>66%</td>
<td>9%</td>
<td>100%</td>
</tr>
<tr>
<td>2022 Low</td>
<td>25%</td>
<td>61%</td>
<td>15%</td>
<td>100%</td>
</tr>
</tbody>
</table>
### Shale Crude vs Displaced Light Imports

<table>
<thead>
<tr>
<th>Property</th>
<th>Bakken</th>
<th>Eagle Ford</th>
<th>Eagle Ford Cond.</th>
<th>Brent</th>
<th>Bonny Light</th>
</tr>
</thead>
<tbody>
<tr>
<td>API Gravity</td>
<td>41</td>
<td>45</td>
<td>56</td>
<td>39</td>
<td>34</td>
</tr>
<tr>
<td>Sulfur, wt%</td>
<td>0.20</td>
<td>0.20</td>
<td>0.15</td>
<td>0.35</td>
<td>0.24</td>
</tr>
<tr>
<td>Distillation Yield, volume %</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lt. Ends, C₁-C₄</td>
<td>3.5</td>
<td>3.8</td>
<td>6.6</td>
<td>3.5</td>
<td>1.3</td>
</tr>
<tr>
<td>Naphtha</td>
<td>35.7</td>
<td>40.1</td>
<td>56.7</td>
<td>24.1</td>
<td>20.3</td>
</tr>
<tr>
<td>Middle Distillates</td>
<td>30.9</td>
<td>29.7</td>
<td>28.6</td>
<td>35.3</td>
<td>45.5</td>
</tr>
<tr>
<td>Gas Oil</td>
<td>24.8</td>
<td>21.2</td>
<td>7.6</td>
<td>27.0</td>
<td>27.4</td>
</tr>
<tr>
<td>Vacuum Residue</td>
<td>5.2</td>
<td>5.2</td>
<td>0.5</td>
<td>10.1</td>
<td>5.4</td>
</tr>
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</table>
## Canadian WCS Quality Shift

<table>
<thead>
<tr>
<th>Property</th>
<th>Current</th>
<th>2022</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>API Gravity</td>
<td>20.3</td>
<td>20.3</td>
<td>- -</td>
</tr>
<tr>
<td>Sulfur, wt%</td>
<td>3.4</td>
<td></td>
<td>- -</td>
</tr>
<tr>
<td>TAN, mg KOH/gm</td>
<td>1.15</td>
<td>1.50</td>
<td>0.35</td>
</tr>
<tr>
<td>Distillation Yield, volume %</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lt. Ends, C₁-C₄</td>
<td>2.7</td>
<td>4.9</td>
<td>2.2</td>
</tr>
<tr>
<td>Naphtha</td>
<td>14.0</td>
<td>15.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Middle Distillates</td>
<td>21.7</td>
<td>17.8</td>
<td>-3.9</td>
</tr>
<tr>
<td>Gas Oil</td>
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<td>31.2</td>
<td>-2.6</td>
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<tr>
<td>Vacuum Residue</td>
<td>27.8</td>
<td>31.1</td>
<td>3.3</td>
</tr>
</tbody>
</table>
## Canadian Heavy vs. Latin Heavies

<table>
<thead>
<tr>
<th>Property</th>
<th>Canadian Heavy (Current)</th>
<th>Canadian Heavy (2022)</th>
<th>Mexican Maya</th>
<th>PDVSA Merey</th>
</tr>
</thead>
<tbody>
<tr>
<td>API Gravity</td>
<td>20.3</td>
<td>20.3</td>
<td>20.5</td>
<td>16.0</td>
</tr>
<tr>
<td>Sulfur, wt%</td>
<td>3.4</td>
<td>3.5</td>
<td>3.7</td>
<td>2.5</td>
</tr>
<tr>
<td>TAN, mg KOH/gm</td>
<td>1.15</td>
<td>1.50</td>
<td>0.20</td>
<td>0.7 – 0.9</td>
</tr>
<tr>
<td>Distillation Yield, volume %</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lt. Ends, C\textsubscript{1}-C\textsubscript{4}</td>
<td>2.7</td>
<td>4.9</td>
<td>0.9</td>
<td>0.1</td>
</tr>
<tr>
<td>Naphtha</td>
<td>14.0</td>
<td>14.9</td>
<td>16.0</td>
<td>7.1</td>
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Quality of U.S. Crude Oil Production

![Graph showing API Gravity and Sulfur, wt. % over time from 2000 to 2022. The API Gravity line is in red and shows a general upward trend. The Sulfur, wt. % line is in green and shows a general downward trend. There is a vertical line indicating a low cases scenario.](image-url)
API Gravity of U.S. Refinery Crude Slate

- High Crude Forecast
- Low Crude Forecast
Crude Exports

- By 2022, N.A. crude production vs. refinery runs will be close to balanced (~18.0 vs. 17.5 MM BPD) if crude exports are allowed.

- Crude exports of ~2.0 MM BPD:
  - Necessary to balance against “structural imports” from PDVSA, Pemex, S.A. etc.
  - Mostly from Eagle Ford, Permian and ANS
  - Canadian will export from both coasts (dependent on midstream expansion)

- Crude access/logistics will continue to be key margin determinant

- Export policy decisions critical
Refinery Yield Impacts

- “Dumbbelling” of Crude Slate
  - Higher LPG and naphtha
  - Lower middle distillate
  - Resid yields up in Canadian heavy crudes; still generally lower than in Latin heavy

- Implications
  - Higher LPG yield adds to surplus from field production
  - Higher naphtha/lower distillate yields runs counter to demand growth patterns
  - Will lead to increasing exports of LPG’s/gasoline; decreasing ability to export diesel
  - Light naphtha surplus a particular issue – some can be used as diluent for Can. bitumen

- Remedies
  - Construction of hydrocracking units – very capital intensive
  - Development of LPG/NGL, light naphtha and gasoline export markets
  - Export of particularly problematic crudes – export limitations; condensate splitting
  - Incentivize high distillateyielding GTL projects
U.S. Net Product Exports

- Gasoline
- Distillates
- LPG/NGL/Other

MBPD

- 2012
- 2014
- 2018
- 2022

Turner, Mason & Company
Consulting Engineers
Final Thoughts

NA Boom in Crude Production
- Significant “game changer” with international implications
- Well decline rates in some tight oil formations are 80%+ but production growth will continue for several years before reaching a plateau
- Permian has the most long-term potential
- Ability to export crude will be key to continued growth

Implications for U.S. Refining Sector
- Less expensive crude
- Lower natural gas cost
- Adds to existing advantages – higher complexity, developed infrastructure, more flexible work force – to make U.S. refineries the most competitive in the world

Facilitates Ability to Export Products – Requirement due to Declining Domestic Demand
- U.S. transitions from big net importer to large net exporter
- Sustainable trend; increased competitiveness of U.S., growing demand in developing countries; lack of success in building/running refineries
Final Thoughts (Cont.)

U.S. Crude Boom Also Presents Challenges

- Will require downstream capex along with investment outside refinery gates
- Major impact on refinery yields/product balances – more gasoline/less diesel
- Particularly long on light naphtha/condensate
- Quality of new production (mostly shale) major unknown

Threats to Product Export Model

- Growing dependence on volatile markets in Latin America and elsewhere
- Dependent on continuing difficulty of countries to supply own demand
- Increasing volumes of gasoline more difficult to place
- Threats from other export refineries – SATORP/Jubail, YASREF/Yanbu, others
- Potential of U.S. export restrictions; unlikely despite political posturing

Regulatory/Policy Issues

- U.S. policy on crude exports
- RFS – Ethanol Blendwall/Soaring RIN Costs/Increasing volumes of alternatives
- Potentially more restrictive CAFÉ standards
- Tier 3 Rules – More investment/increased costs
- Carbon restrictions –tax/cap and trade/LCFS
- Other – XL pipeline approval?/LS heating oil, bunker fuel/Jones Act
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