The Long and Winding Road
Changing Canadian Crude Qualities and Strategies

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Senior Consultant
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Director/Head of Calgary Office

COQA Fall 2019 Meeting
Dallas, TX
October 10, 2019
Agenda

• The Past and Present

• An Alphabet Future – IMO, KXL/TMX, CBR, TAN, PUB, etc.
Evolving Canadian Crude Market

- High level of interdependence between U.S. and Canada
- Developments in LatAm and elsewhere increasing importance of Canadian supply for USGC refiners
- Logistics limit access to refining markets
- Qualities can be “shaped” by investment in Canada

WCSB Supply and U.S. Exports

- Canada becomes largest exporter of crude to U.S.
  - PADD II ~100% of imports
  - ~70% of total crude
  - PADD III ~30% of heavy crude supply
High level of interdependence between U.S. and Canada
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- PADD III ~30% of heavy crude supply

WCSB Supply and U.S. Exports

- Enbridge Line 3 Replacement
- TMX Pipeline Expansion
- TMX PL purchased by Government
- Alberta production curtailment by Government
- Keystone XL rejected by Obama Administration
- Horizon Exp / to 250 MBPD
- TMX PL Expansion
- Alberta Clipper PL / 450 MBPD
- Alberta Clipper PL Expansion to 800 MBPD
- Flanagan South (to Cushing) / 590 MBPD
- Keystone XL purposed
- WCS launched as benchmark crude
- Aurora North / 225 MBPD
- Foster Creek (1st Commercial SAGD)
- Express PL / 280 MBPD
- Firebag / 203 MBPD
- Muskeg River / 155 MBPD
- Jackpine / 100 MBPD
- Keystone PL / 590 MBPD
- Keystone XL
- Kearl / 110 MBPD
- Fort Hills / 194 MBPD
- Kearl Exp / to 220 MBPD
- MarketLink / 830 MBPD
- Seaway Exp. / to 800 MBPD
- IMO Bunker Fuel Sulfur Regulations
- Express PL / 280 MBPD
- Horizon / 110 MBPD
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Canadian Discount – Highly Volatile Due to Logistical Limitations

Maya (FOB Mexico) - WCS (Hardisty)

Maya (FOB) - WCS (Hardisty)  Canada CBR Exports (Right Axis)

Maya (FOB Mexico) - WCS (Hardisty) due to logistical limitations, with highly volatile prices and Canadian Discount.

- Pipeline
- Unit Train Rail

Canadian Discount is highly volatile due to logistical limitations.
Canadian Discount – Highly Volatile Due to Logistical Limitations

Maya (FOB Mexico) - WCS (Hardisty)

No link from Alberta to USGC!
Canadian Discount – Highly Volatile Due to Logistical Limitations

Maya (FOB Mexico) - WCS (Hardisty)

- WCSB production overwhelms PADD II refining capacity → New pipeline and CBR investments
- No link from Alberta to USGC!

Due to logistical limitations, there is a highly volatile discount between Maya (FOB Mexico) and WCS (Hardisty). The WCSB production overwhelms the PADD II refining capacity, leading to the need for new pipeline and CBR investments. There is no direct link from Alberta to the US Gulf Coast (USGC), contributing to the volatility in the discount.
Canadian Discount – Highly Volatile
Due to Logistical Limitations

Maya (FOB Mexico) - WCS (Hardisty)

- No link from Alberta to USGC!
- WCSB production overwhelms PADD II refining capacity → New pipeline and CBR investments
- Keystone MarketLink (Cushing to Houston)
- Seaway Twin (Cushing to Houston)
- Flanagan South (Flanagan, IL to Cushing)

$/BBL


Thousands BPD

Flanagan South (Flanagan, IL to Cushing)
Seaway Twin (Cushing to Houston)
Keystone MarketLink (Cushing to Houston)
WCSB production overwhelms PADD II refining capacity → New pipeline and CBR investments
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Keystone MarketLink (Cushing to Houston)

Horizon Ph 3 (Production +85 MBPD)

Fort Hills (Production +194 MBPD)

Seaway Twin (Cushing to Houston)

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Unit Train Rail

Pipeline

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TAN Discounts Are Volatile/Hard to Estimate

- Dependent on supply/demand – volume of high TAN vs. “metalled up” refineries
  - Short term volatility from T/A’s, supply outages, etc.
- Decreases as investment made to handle high TAN
- Mitigation strategies (blending, inhibitors, inspection) can be used on moderate TAN
- Other market/commercial factors also affect value; difficult to isolate TAN impact

Calculated TAN/Other Market Discount – ex. Refining Value

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<thead>
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*Mid-continent USGC*
Agenda

• The Past and Present

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AWB Refinery

Refinery Unit Capacities (MB/SD)- Access Western Blend

- CDU 200
- VDU 126
- Distillate HTU 34
- Hydrocracker 75
- Delayed Coker 78
- Sulfur Recovery 1810 ton/day
- Hydrogen Plant 144
- Purchased Natural Gas 10787
- LPG Sales 8334
- Offgas C2 17,605
- LPG Recovery 26
- C3/C4 LSR Isom 26
- Hypochlorite 10,566 ton/day
- Distillate HTU 79
- Refiner 57
- Naphtha HTU 79
- 0.5% Sulphur No.6 Fuel C 7,744

Assumes 94% onstream factor

Assumes all naphtha is processed in refinery

Diluent Sales 70 k BPD

Access Western Blend 200,000 BPD

Gasoline 38,974 57,214

ULSD 67,618

Distillate HTU

CDU

VDU

Delayed Coker

Naphtha HTU

Hydrocracker

Sulfur Recovery

Purchased Natural Gas

Hydrogen Plant

10,566 ton/day

985 MMSCFD

985 MMSCFD

Hydrogen

10787

Turner, Mason & Company 
energy consulting & advisory
Partial Upgrader SDA

Diluent Sales 3273 t/d
32,984 b/d AGO
VGO
Diluent +
ADU VDU
Diluted Bitumen DAO+AGO+VGO 22260 t/d
29,880 t/d
18986.67 t/d
19.0 API
22,607 t/d Raw Bitumen
13 API
940 kg/m³
7,273 t/d Diluent
84%
148,950 b/d
200,000 b/d dilbit
Asphaltene
3613 t/d
16%
Deasphalting Partially Upgraded

200,000 b/d dilbit

Diluent + Partially Upgraded

148,950 b/d
Partial Upgrader SDA+MTC

**Unit Capacities (MB/SD)**

<table>
<thead>
<tr>
<th>Process</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diluent Recovery</td>
<td>200</td>
</tr>
<tr>
<td>Deasphalting</td>
<td>106</td>
</tr>
<tr>
<td>Mild Thermocracking</td>
<td>91</td>
</tr>
<tr>
<td>Hydrotreating</td>
<td>8.7</td>
</tr>
</tbody>
</table>

(1) Assumes 94% onstream factor
(2) Includes acid gas processing and sulphur recovery
Partial Upgrading – Not an Entirely New Concept

• Suncor OCC and OSH
  – Cracked products from delayed coker (OCC & PBS), and virgin VGO+ (OSH)
Partial Upgrading – Not an Entirely New Concept

- Suncor OCC and OSH
  - Cracked products from delayed coker (OCC & PBS), and virgin VGO+ (OSH)
- Albian Heavy Synthetic (AHS)
  - Blend of LCF Bottoms produced at Scotford Upgrader and other crudes
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  - Rejection of up to 50% asphaltenes in Froth Treatment process
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  - Blend of LCF Bottoms produced at Scotford Upgrader and other crudes
- Paraffinic Froth Treatment
  - Rejection of up to 50% asphaltenes in Froth Treatment process
- Solvent Assisted SAGD
  - Several producers are testing use of solvent in various forms to produce partially deasphalted bitumen (Imperial, MEG, Cenovus, etc.)
The New PUBs

• A Variety of Options/Multiple Developers
  – CNOOC/Nexen, MEG, Husky, Field Upgrading, Value Creation (VCI), Fractal Systems, multiple others
  – Level of upgrading varies – can produce PUB to compete with medium to heavy crudes; some processes even target IMO compliant bunker market
  – Start up dates being discussed are 2022+
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• Alberta Government PUB Program
  – DOE/AI working with developers on options
  – TM&C conducted AI sponsored study in 2018/19 on market value/quality issues of various PUBs
  – Environment changing under new AB government
# Greenfield Upgrader Cost Estimate

## TABLE V - 1

**SCO Upgrader Capital Cost Estimate**  
(Constant 2019 U.S. Dollars)

<table>
<thead>
<tr>
<th>Unit</th>
<th>Capital Cost(1) $Million</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude Distillation Unit</td>
<td>213</td>
</tr>
<tr>
<td>Vacuum Distillation Unit</td>
<td>139</td>
</tr>
<tr>
<td>Delayed Coker</td>
<td>86</td>
</tr>
<tr>
<td>Naphtha Hydrotreater</td>
<td>29</td>
</tr>
<tr>
<td>Distillate Hydrotreater</td>
<td>37</td>
</tr>
<tr>
<td>AGO Hydrotreater(2)(6)</td>
<td>84</td>
</tr>
<tr>
<td>Hydrogen Plant(8)</td>
<td>153 MMSCFD</td>
</tr>
<tr>
<td>LPG Recovery</td>
<td>10</td>
</tr>
<tr>
<td>Sulfur Recovery(8)</td>
<td>857 LIT/D</td>
</tr>
<tr>
<td><strong>Total Onsite</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Total Offsite(3)</strong></td>
<td></td>
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<tr>
<td><strong>Total Refinery</strong></td>
<td></td>
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<tr>
<td>Licensor Costs(4)</td>
<td></td>
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<tr>
<td>Owner’s Costs(5)</td>
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<tr>
<td>Escalation(6)</td>
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<tr>
<td>Contingency(7)</td>
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<tr>
<td><strong>Grand</strong></td>
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</tbody>
</table>

Notes: (1) Process units are inside battery line and (ISBL) Costs. All costs have been increased based on 2.0 location factor adjustment relative to U.S. Gulf Coast.

Notes: (3) Offsites cost include tank farm, piping, power distribution, steam generating and distribution, water treating, and asphaltene handling.

Notes: (4) Licensor costs include fees, engineering and initial fill.

Notes: (5) Owners costs include project management, startup and调试.

Notes: (6) Escalation is 3%.

Notes: (7) Contingency is 15%.

Notes: (8) Two trains
Pipe vs. Crude by Rail Assessment

Rail provides options:

- Reach markets not served by pipeline
- Can rail undiluted bitumen in C&I tankcars
- Rail can be deployed in relatively short timeframe
- Several origination and destination options exist in Western Canada and USGC, USMC.

<table>
<thead>
<tr>
<th></th>
<th>Edmonton to St James, LA US$/barrel dilbit 10 year Committed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enbridge Tariff</td>
<td>$ 8.70</td>
</tr>
<tr>
<td>Power</td>
<td>$ 0.21</td>
</tr>
<tr>
<td>Working Capital Charge</td>
<td>$ 0.90</td>
</tr>
<tr>
<td>Tankage &amp; Terminal Fees</td>
<td></td>
</tr>
<tr>
<td>Cushing, OK</td>
<td>$ 0.40</td>
</tr>
<tr>
<td>Beaumont, TX</td>
<td>$ 0.60</td>
</tr>
<tr>
<td>St. James, La</td>
<td>$ 0.80</td>
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<tr>
<td>Bayou Bridge Toll</td>
<td>$ 1.70</td>
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<tr>
<td>Edmonton to St James per bbl bler</td>
<td>$ 13.31</td>
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<tr>
<td>Edmonton to St James per bbl bitu</td>
<td>$ 19.30</td>
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<tr>
<td>Diluent Penalty</td>
<td>$ 3.59</td>
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<tr>
<td>Total/ bbl bitumen</td>
<td>$ 22.89</td>
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Dilbit / PUB Quality Issues

<table>
<thead>
<tr>
<th>Crude Name</th>
<th>DilBit</th>
<th>PUB 1&lt;sup&gt;(1)&lt;/sup&gt;</th>
<th>PUB 2&lt;sup&gt;(1)&lt;/sup&gt;</th>
<th>Maya</th>
<th>Castilla</th>
<th>Mars</th>
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<tbody>
<tr>
<td>API Gravity</td>
<td>20.7</td>
<td>19.4</td>
<td>19.5</td>
<td>22.3</td>
<td>19.9</td>
<td>29.8</td>
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<tr>
<td>Sulfur (wt %)</td>
<td>3.70</td>
<td>3.39</td>
<td>3.33</td>
<td>3.38</td>
<td>1.88</td>
<td>1.72</td>
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<tr>
<td>K Factor</td>
<td>11.61</td>
<td>11.37</td>
<td>11.26</td>
<td>11.54</td>
<td>11.54</td>
<td>11.49</td>
</tr>
<tr>
<td>TAN</td>
<td>2.3</td>
<td>1.6&lt;sup&gt;(2)&lt;/sup&gt;</td>
<td>1.0&lt;sup&gt;(2)&lt;/sup&gt;</td>
<td>0.3</td>
<td>0.3</td>
<td>&lt;0.1</td>
</tr>
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<sup>(1)</sup>Includes diluent as necessary to meet pipeline specs

<sup>(2)</sup>PUB TAN can vary considerably based on specific upgrading process used
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Much higher sulfur than some heavy crudes and most traditional medium crudes

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<td>Sulfur (wt %)</td>
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<td>11.49</td>
</tr>
<tr>
<td>TAN</td>
<td>2.3</td>
<td>1.6&lt;sup&gt;(2)&lt;/sup&gt;</td>
<td>1.0&lt;sup&gt;(2)&lt;/sup&gt;</td>
<td>0.3</td>
<td>0.3</td>
<td>&lt;0.1</td>
</tr>
</tbody>
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Poor FCCU feed properties. Higher UOP K in DilBit is misleading/due to diluent addition/leads to poor reformer feed with no gas oil benefits

Much higher sulfur than some heavy crudes and most traditional medium crudes

<sup>(1)</sup>Includes diluent as necessary to meet pipeline specs

<sup>(2)</sup>PUB TAN can vary considerably based on specific upgrading process used
## Dilbit / PUB Quality Issues

<table>
<thead>
<tr>
<th>Crude Name</th>
<th>DilBit</th>
<th>PUB 1(^{(1)})</th>
<th>PUB 2(^{(1)})</th>
<th>Maya</th>
<th>Castilla</th>
<th>Mars</th>
</tr>
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- Poor FCCU feed properties. Higher UOP K in DilBit is misleading/due to diluent addition/leads to poor reformer feed with no gas oil benefits.
- Much higher sulfur than some heavy crudes and most traditional medium crudes.
- Bitumen is very high TAN, but upgrading can reduce TAN by varying amounts based on upgrading technology used.

\(^{(1)}\)Includes diluent as necessary to meet pipeline specs
\(^{(2)}\)PUB TAN can vary considerably based on specific upgrading process used.
PUB – Beer Belly instead of Dumbbell

Labels Represent Volume Percent of Material Boiling Between 330 F and 1050 F

- **Bitumen**: 52.8%
- **DilBit**: 45.6%
- **PUB 1**: 60.6%
- **PUB 2**: 75.4%
- **WCS**: 53.6%
- **Maya**: 52.9%
- **Mars**: 58.5%

*Includes diluent as necessary to meet pipeline specs*
PUB – Beer Belly instead of Dumbbell

Labels Represent Volume Percent of Material Boiling Between 330 F and 1050 F

*Includes diluent as necessary to meet pipeline specs
PUB – Replacement Cracking Crude in a Post-IMO World

Difference in VTB yield spread relatively evenly between remaining cuts

45% Reduction in VTB yield with PUB / WTL blend

*Includes diluent as necessary to meet pipeline specs
PUB 1 (w/ 17.5 vol % Diluent) – Several $/B More Valuable Than Other Heavies
PUB 2 (w/ 3 vol % Diluent) – More Valuable Than Medium Sours
Final Takes

- **Canadian Developments Critical to both U.S. and Canada**
  - Removing takeaway limitations key to growth
  - USGC refiners thirsting for replacements to LatAm heavies
  - Potential replacement for declining local heavy in California
  - CBR provides interim alternative if P/L delays persist

- **PUB concept provides multiple benefits**
  - Increased refining value
  - Expanding market beyond deep conversion/IMO advantages
  - Diluent reduction/opportunity to “stretch” takeaway capacity
  - Lower capital vs. full upgrading/key in high cost environment

- **Quality considerations key to market value/acceptance**
  - Refiners have to get comfortable with cracked components
  - Sulfur a key issue in California
  - TAN an issue in new markets, including Asia

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CLEARING THE BITUMEN BOTTLENECK

ASSESSING PROCESSING, TRANSPORTATION AND MARKETING OPTIONS FOR ALBERTA BITUMEN

Lead Authors – Ed Koshka, P.Eng
John Auers, P.E.
Robert Auers

SUPPORTED BY TM&C OUTLOOK TEAM
DALLAS, CALGARY AND HOUSTON

OCTOBER 2019
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