MEG/WRI’s Partial Bitumen Upgrader Project – Adding Value to MEG and Alberta

February 2015
Presentation Format

- Who we are - MEG and WRI
- Introduction to Alberta oil sands
- Resource recovery, transportation and current distribution practices/issues
- Bitumen partial upgrading
- MEG/WRI upgrader development program
- Summary – How we are adding value
Western Research Institute

• Founded in 1924 as a laboratory within U.S. Bureau of Mines
  o Petroleum research station to support development of Wyoming’s petroleum resources
  o 1960’s the research role was expanded to include research on other petroleum, oil shale, coal, and Utah tar sands (oil sands)
  o In 1977, the facility was included with other laboratories to form U.S. Department of Energy
• In 1983 the U.S. Department of Energy de-federalized three laboratories including the Laramie center
  o Western Research Institute was then established as an independent research corporation associated with the University of Wyoming
Western Research Institute

- WRI conducts research in:
  - Advanced energy systems (coal)
  - Environmental technologies
  - Highway materials (asphalt) and heavy oil chemical research
  - Heavy oil (bitumen) processing and upgrading (HOTC)

- WRI operates two facilities:
  - 9th and Lewis facility – laboratory space for highway materials research
  - Advanced Technology Center (ATC) for pilot plant testing (HOTC is at the ATC)
MEG Energy

- MEG (McCaffrey Energy Group) is an oil sands production company providing energy to markets across much of North America
- MEG was founded in 1999 and became publicly traded in 2010
- The production assets are located entirely in Alberta (Christina Lake) —
  - Production at 76,000+ bbl/d
- Head office in Calgary, Alberta, Canada
- Other holdings:
  - Stonefell Terminal (900,000 bbl storage)
  - Access Pipeline (half ownership)
- Number of employees and full time contractors is about 700
Recovery, Transportation and Distribution
Alberta Oil Sands

- Alberta oil sands are composed of quartz sand, surrounded by a layer of water and clay, and then covered by bitumen (the hydrocarbon)
Alberta Oil Sands

- Alberta oil sands are located in three major deposits; Athabasca, Peace River and Cold Lake

- Estimated size
  - 1.7 - 2.5 trillion barrels in place
  - 170 billion barrels recoverable – third to Saudi Arabia and Venezuela
## Current Alberta Production

<table>
<thead>
<tr>
<th>Percentage of Available Resource</th>
<th>2011</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mine Recovered Oil Sands</td>
<td>20</td>
<td>0.89</td>
</tr>
<tr>
<td>Insitu Recovered Oil Sands</td>
<td>80</td>
<td>0.85</td>
</tr>
<tr>
<td>Total Production</td>
<td>1.74</td>
<td>1.95</td>
</tr>
</tbody>
</table>

Million bbl/day (CAPP, 2014)

- Alberta ranks 5\textsuperscript{th} globally in oil production
  
  U.S. Department of Energy - 2013

- 33.3\% of U.S. oil imports are from Alberta
  
Current Alberta Production

Increase is caused by displacing Venezuelan and Mexican heavy crudes in Gulf-coast refineries

U.S. crude oil imports from Canada

- 3.0 million barrels a day
- Source: U.S. Energy Dept. (imports); CQG (price difference)

Difference, in U.S. dollars, between Canada’s WCS crude oil and WTI

- $13.20 below WTI (a barrel)
- The Wall Street Journal
  1/13/15
Current Alberta Production

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Current Alberta Production

- U.S. demand for heavy oil imports from Alberta are increasing
  Wall Street Journal 10/8/14

  ✓ Keystone Pipeline will improve the opportunity to increase oil sands production and US imports

  ✓ Trans-rail facility ($60 M) planned for Casper, WY will increase use capacity of the Express pipeline
SAGD Oil Sands Recovery

- **SAGD Technology**
  - Well pairs are drilled into the formation
  - Steam is pumped into
  - SOR is normally 3

- **MEG’s SAGD Performance**
  - SOR typically below 2.5
  - 90% of water recycled
  - Uses no surface water
  - Small environmental footprint

MEG is the industries' 2nd lowest cost producer!

The Wall Street Journal, 1/13/15
SAGD Christina Lake Site
The Opportunity
Pipeline Specifications

Bitumen will require dilution or upgrading to meet specifications

<table>
<thead>
<tr>
<th></th>
<th>Bitumen</th>
<th>Pipeline Spec.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Gravity (g/cc)</td>
<td>1.014</td>
<td>&lt; 0.940</td>
</tr>
<tr>
<td>API Density (°API)</td>
<td>8.0</td>
<td>&gt; 19</td>
</tr>
<tr>
<td>Viscosity (cSt)</td>
<td>166,000,000</td>
<td>&lt; 40,000</td>
</tr>
</tbody>
</table>

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Dilution to Meet Pipeline Specs

- **Dilbit** – bitumen diluted with a diluent (naphtha)
  - Typical diluent is natural gas condensate
  - 20 – 50% dilution
  - Condensate is in high demand
    - \( \downarrow \) = \$↑
  - High differential for dilbit
  - Limits pipeline capacity
- **Synbit** – bitumen diluted with syncrude (SCO)
  - Higher cost of SCO
  - Lower differential
  - Low market share and growth
Partial Upgrading of Oil Sands

- Delayed coking – industry standard for partial bitumen upgrading is a two-stage process to produce SCO
  - First stage is distillation to recover lower boiling components
  - Second stage is delayed coking to convert residuum to lighter products
- Low yield - 75 to 80% (vol.)
- Large environmental footprint
- SCO has limited market growth
- Product (sour syncrude) will meet pipeline specifications
The Problem Faced by Producers

• The problem:
  – Diluent supply does not meet the demand
    • Resulting in high operating cost
    • Limits pipeline capacity
  – Distillation/delayed coking has low yield and product quality
    • Low added value equates to limited market growth
    • Large environmental footprint

The industry needs a technically and economically viable upgrader that is environmentally friendly to add value, remain competitive and keep production costs down.
MEG/WRI Partial Upgrader Development

Historical Timeline

- **2000** – MEG/WRI relationship established
- **2004** – Initiated jointly-sponsored research program with MEG, WRI and US DOE
- **2007** – Completed operation of a 1-bbl/d MDRU process development unit
- **2008** – Installed 5-bbl/d MDRU pilot plant in the Heavy Oil Technology Center (HOTC)
- **2010** – Completed evaluation of MDRU
- **2011** – Installed 5-bbl/d companion solvent extraction pilot plant
- **2012** – Funding and site secured for 1,500 bbl/d demonstration unit near Edmonton
- **2012** – Process engineering initiated for demo
- **2014** – Construction of demo started
MEG/WRI Partial Upgrader - PFD

Diluted Bitumen → Diluent Removal

Diluent Return to Production Site

Bitumen → Thermal Conversion

DAO → HI-Q® Product

Overhead

Asphaltene Recovery

Solvent Deasphalting
HI-Q® Properties

- Meets pipeline density and viscosity specifications without adding diluent
- High Yield - 90% (vol.) yield
- Increased marketability
  - Lower MCR – reduced coke formation
  - Reduced TAN – less corrosion
  - Reduced metals content
  - Nearly asphaltene free

<table>
<thead>
<tr>
<th>Property</th>
<th>Bitumen</th>
<th>HI-Q®</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density (°API)</td>
<td>8.0</td>
<td>20.1</td>
</tr>
<tr>
<td>Viscosity (cSt)</td>
<td>166,000,000</td>
<td>58.5</td>
</tr>
<tr>
<td>MCR (wt %)</td>
<td>15.5</td>
<td>2.7</td>
</tr>
<tr>
<td>TAN</td>
<td>2.5</td>
<td>0.29</td>
</tr>
<tr>
<td>Nickel (ppm wt)</td>
<td>104.0</td>
<td>5.4</td>
</tr>
<tr>
<td>Vanadium (ppm wt)</td>
<td>279.4</td>
<td>10.1</td>
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</table>
**HI-Q® Composition**

- **Composition:**
  - Vacuum residue is reduced from 58 to 18% of the product
  - Naphtha production is minimized and represents about 10% of the product
  - Portions with the highest value – kerosene, diesel and gas oils – represent the largest fraction of the product
  - HI-Q® is nearly asphaltene free

![Diagram showing composition](image)

**Legend:**
- Green: Naphtha
- Blue: Kerosene & Diesel
- Red: Gas Oils
- Gray: Vacuum Residue

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Refining End of the Value Chain

- Two types of refineries – cracking and coking
  - Based on feedstock type – light or heavy crude oil
- Refining is a margin-based business
  - Market floats with no fixed prices

Light Crude & SCO

Cracking refinery
$5 - 6/bbl margin
Sustainable but no growth
No growth = no feedstock growth

Heavy Crudes, Dilbit & HI-Q®

Coking refinery
$21 - 23/bbl margin
15%+ IRR, strong growth
Strong growth = feedstock growth
Upgrading to HI-Q® has high potential for feedstock market growth
Refinery Yields – Dilbit vs HI-Q®

Refinery Liquids Yields

<table>
<thead>
<tr>
<th>Volume Percent of Feed</th>
<th>Dilbit</th>
<th>Dilbit Products</th>
<th>HIQ</th>
<th>HIQ Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>20%</td>
<td></td>
<td></td>
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<tr>
<td>40%</td>
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<tr>
<td>60%</td>
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<tr>
<td>80%</td>
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<td></td>
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<tr>
<td>100%</td>
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<tr>
<td>120%</td>
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- 83.5% Dilbit
- 103.2% HIQ

20% more refinery liquid product per feed barrel

MEG Energy

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Well-to-Wheels GHG Comparison

There is a 44% reduction in GHG when compared directly to delayed coking.
Program Status

WRI 5 bbl/d pilot plant operating since 2008

- Process development and refinement will continue during development phase – risk mitigation
- An optimization program has commenced
- Additional validation work will continue for the long term

A 1500 bbl/d Commercial Demonstration plant has been approved and is currently in the engineering and construction phase

- Located adjacent to rail access and storage in the Heartland area.
- Fully permitted for construction
- Detailed design complete

Product Distribution:

- HI-Q® Product will be moved by rail
- Diluent will be returned to MEG’s production facilities by the Access pipeline.
- Sulphur production will move by rail
Demonstration - Goals

1. Minimize scale-up risk by:
   • Confirming performance variables with equipment at scale
   • Reliability, Availability, Maintainability determination
     • Run facility continuously to address operability issues

2. Produce sufficient industrial quantities of HI-Q® for:
   • Customer testing to evaluate product quality
   • Gauging and developing market acceptance

3. Validate Economic Model through:
   • Improving cost estimate for commercial unit
   • Providing framework for licensing strategy
   • Updated validation of revenue generation
Alberta Heartland Location
Value Added Summary

- All upgrading will be done in Alberta – adding value to MEG in Alberta’s Industrial Heartland
- HI-Q® product meets pipeline specifications without the need for added diluent
  - Reduces diluent costs
  - Increases pipeline capacity for marketable product
- 44% reduction in carbon foot print as compared to the industry standard – delayed coking
- HI-Q® product yield is 90% and compared with 80% for conventional upgrading (delayed coking)
- HI-Q® is upgraded to reduce TAN, MCR and metals
Value Added Summary

✓ HI-Q® is anticipated to be more attractive to refiners than bitumen/dilbit or SCO:
  ➢ Matches with coking refineries – strong feedstock growth
  ➢ Reduced asphaltene content to minimize coke formation
  ➢ Reduced residuum content – higher refinery yield
  ➢ Increased gas oil content for transportation fuels – high value component
  ➢ Minimal naphtha fraction – low value component
  ➢ Higher refinery yield – particularly in the diesel fuel range