Partial Upgrading of Bitumen

Impact on Crude Quality

Presented to the joint COQA/CCQTA Meeting
Denver, Colorado
May 2018
Overview

• Interest in partial upgrading of bitumen
• Alberta Government incentives
• Partial upgrading is?
• Range of technologies under development
• Impact on crude quality
• CCQTA initiatives
• Conclusions
• Reference
Partial Upgrading in Alberta

- New Alberta Government incentives in place to encourage technology development

Motivation

- **Diluent avoidance**
  - Diluted bitumen is up to 30% natural gas condensate
    - Estimated cost US$14/bbl *
  
- **Market access issues**
  - Pipeline limitations

- **Quality improvements over bitumen**
  - Marketability and value

- **New market opportunities**
  - Reduced bottoms can fit more refineries

- Provide options for bitumen producers

* Jacobs Consultancy  Bitumen Partial Upgrading Whitepaper – March 2018 AM 401A Alberta Innovates
Partial Upgrading in Alberta

- Government Incentives
  - $1 billion offered to support development

Alberta to invest $1 billion over eight years in bitumen upgrading

The cash injection comes as a result of recommendations made by Alberta’s energy diversification advisory committee, released Monday.

The province plans to spend up to $1 billion over the next eight years for new partial upgrading facilities in Alberta to diversify the energy sector.

The government hopes it will attract as many as five new upgrading facilities, representing $5 billion in private investment and 4,000 construction jobs.

Source: Edmonton Journal Feb 26, 2018
National Partial Upgrading Program

• Initiated by Alberta Innovates in 2014 to get Alberta’s bitumen resources to market
  - A combined government and industry group
  - Pools national ingenuity
  - Find the most environmentally friendly and economically-sustainable methods to transform bitumen

• NPUP created to identify technologies that upgrade bitumen to meet the minimum pipeline specifications at a low cost
National Partial Upgrading Program

• Alberta Innovates recently released Whitepaper (Jacobs Consultancy) – May 2018 *
  - Scan and evaluate 25 partial upgrading technologies at various stages of development
    → Results will help determine which technologies are ready for more detailed evaluation and development

• Key conclusion:
  - Multiple technologies under development making different products
  - More R&D work needed to better understand the impact of partially upgraded product quality on refinery processability and value

* Report link at the end of the presentation
Partial Upgrading

- Partial upgrading of bitumen produces a refinery feedstock product
  - *In between bitumen and full SCO*

- Target is to upgrade bitumen sufficiently that it does not require pipeline diluent
  - *Freeing up pipeline capacity (30%)*

- A range of technologies have been evaluated
  - *Development, pilot, field demonstration → commercial*

- Partial upgrading could takes place in the field near the wellhead
  - *Central stand alone or bolt-on to production facility*
Partial bitumen upgrading of SAGD produced bitumen can be located either at the production site or a central “stand-alone” facility.
Processing Objective

• The proven technologies that achieve the necessary results involve a combination of:
  - Thermal cracking
  - Carbon rejection
  - Hydrogen addition

• Developmental technologies can include new approaches:
  - Fluid mechanical techniques
  - Catalysts and additives

• The prescribed goal is to upgrade bitumen to meet pipeline specifications
  - Outside the range
    → Undiluted bitumen shipped by rail
    → Bitumen to finished products
Partial Upgrading Goals

- Low cost, low intensity processing
- Various approaches with a range of products
- Primary processing target:
  - Convert bitumen to a product that does not require diluent for common carrier pipeline transport
- Pipeline specifications:
  - 19 API
  - 350 cSt at ground temperature
  - Bottoms Sediment and Water < 0.5 vol%
  - Olefins < 1 wt% (as measured by NMR)
- Product must be suitable for refinery processing
  - Control of contaminants and undesirables
Partial Upgrading Developers

- Partial upgrading of bitumen to a pipelineable typically takes one of two pathways using thermal conversion:
  
 cestor item of the following:
  - No rejected material
    - This minimizes cost and maximizes yield
    - Partial conversion of heavy components
    - No rejection of contaminants
  - Asphaltene removal
    - Thermal conversion with removal of a portion of the asphaltenes
    - Achieve pipeline specifications and simultaneously improve the value of the partially upgraded product
Partial Upgrading Developers

- Thermal conversion is at the heart of all promising technologies
  - Mature enough to consider for demonstration or commercialization
  - Low cost

- Thermal processing remain poorly understood
  - Despite long use in petroleum refinery processing
  - This may impact the valuation of partially upgraded bitumen-derived crude oils

- Potential risks of making products that are not well received or valued by the market
Challenges

• Key factors associated with successful deployment of partial upgrading in Alberta:
  ✦ Changing market conditions
  ✦ Logistical barriers
  ✦ Mismatch between properties desired by crude oil refiners and achieved by partial upgrading
  ✦ High capital and operating costs
  ✦ Yield loss
  ✦ GHG impact
  ✦ Lack of scale
  ✦ Technical risks

• Need a solid technical basis to support a viable business case
Progress

• Work is progressing on technology development through:
  ✪ Multiple pilot plants are planned or have been built
  ✪ Research and Development continues
    ➔ New and different technologies
  ✪ Field demonstration unit construction

• Government support, both Federal and Provincial is being promoted to mitigate challenges
Considerations

• Technology success parameters based on:
  • Market
    ➔ What product is produced
  • Technical performance
    ➔ Yield, quality, and environmental
  • Cost
    ➔ Capital and operating

• Screening of technology options intended to:
  • Inform the identification and selection of appropriate technologies
  • Technology that is suitable to be developed and supported by industry and government consortium investments
Technology Review

• 25 technologies identified
• Screened related to:
  ✨ Ability to produce partially upgraded bitumen meeting pipeline specifications (API, Viscosity, Olefins)
  ✨ Upgrading steps
    → Primary, secondary and treating
  ✨ Viability of technology
    → Technical and product market basis
  ✨ Environmental performance
    → GHG production relative to baseline
  ✨ Field vs central
    → Bolt on vs stand alone
### Technology Review

**Commercially Demonstrated**

<table>
<thead>
<tr>
<th>Technology</th>
<th>Process Type</th>
<th>Partially Upgraded Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delayed Coking</td>
<td>Severe thermal cracking</td>
<td>exceeds</td>
</tr>
<tr>
<td>Mining PFT (Paraffinic Froth Treatment)</td>
<td>Asphaltene removal</td>
<td>meets - with diluent</td>
</tr>
<tr>
<td>Solvent Deasphalting</td>
<td>Asphaltene removal</td>
<td>meets - with diluent</td>
</tr>
<tr>
<td>SELEX-Asp (solid asphaltene removal)</td>
<td>Asphaltene removal</td>
<td>meets - with diluent</td>
</tr>
<tr>
<td>Visbreaking</td>
<td>Mild thermal cracking</td>
<td></td>
</tr>
<tr>
<td>Alberta Taciuk Retort Process (ATP)</td>
<td>Severe thermal cracking</td>
<td>exceeds</td>
</tr>
<tr>
<td>Expander Energy FT Crude</td>
<td>Asphaltene removal + asphaltene gasification + Fischer Tropsch</td>
<td>exceeds</td>
</tr>
</tbody>
</table>

Partially upgraded target is product that meets pipeline specifications for API gravity, viscosity and olefins.
## Technology Review

### Field Demonstration

Field demonstration units typically sized for 1,000 – 1,500 BPD

<table>
<thead>
<tr>
<th>Technology</th>
<th>Process Type</th>
<th>Partially Upgraded Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fractal Systems Jet Shear™ / Enhanced Jet Shear™</td>
<td>mild thermal cracking + fluid mechanical</td>
<td>meets - with diluent</td>
</tr>
<tr>
<td>Fluid Oil Viscositor (Ivanhoe HTL)</td>
<td>severe thermal cracking</td>
<td>exceeds</td>
</tr>
</tbody>
</table>
### Technology Review

#### Under Development

<table>
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<tr>
<th>Technology</th>
<th>Process Type</th>
<th>Partially Upgraded Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Husky HDR™ - Hydrogen Donor Cracking with SCO</td>
<td>mild thermal</td>
<td>meets</td>
</tr>
<tr>
<td>MEG HI-Q® Partial Upgrading Technology</td>
<td>mild thermal + solid asphaltene removal</td>
<td>meets</td>
</tr>
<tr>
<td>Nexen's BituMax™ Partial Upgrading Technology</td>
<td>asphaltene removal + mild thermal</td>
<td>meets</td>
</tr>
<tr>
<td>VCI's ADC and COC Technologies</td>
<td>solid asphaltene removal + severe thermal cracking</td>
<td>meets</td>
</tr>
<tr>
<td>Water-Based Supercritical Solvent Extraction (JGC)</td>
<td>mild thermal + water extraction</td>
<td>meets</td>
</tr>
<tr>
<td>Hydrovisbreaking</td>
<td>mild thermal + hydrotreating</td>
<td>May meet</td>
</tr>
<tr>
<td>ETX Systems IYQ Technology</td>
<td>severe thermal cracking</td>
<td>exceeds</td>
</tr>
<tr>
<td>Field Upgrading - Molten Sodium Upgrading</td>
<td>direct sulphur removal + sodium regeneration</td>
<td>exceeds on sulphur</td>
</tr>
<tr>
<td>Water-Based Catalytic Visbreaking (Aquaconversion)</td>
<td>mild thermal</td>
<td>does not meet</td>
</tr>
<tr>
<td>Superior Upgrading Tech./Hammer Technology</td>
<td>fluid mechanical</td>
<td>unknown</td>
</tr>
</tbody>
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Lab tested at bench scale and pilot plant, leading to field demonstration

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Technology Review

Other

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<thead>
<tr>
<th>Technology</th>
<th>Process Type</th>
<th>Partially Upgraded Target</th>
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</thead>
<tbody>
<tr>
<td>Novel Diluent</td>
<td>dilution with non-traditional</td>
<td>not met</td>
</tr>
<tr>
<td></td>
<td>diluents</td>
<td></td>
</tr>
<tr>
<td>Bitumen solidification</td>
<td>Encapsulation</td>
<td>not met</td>
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<tr>
<td>Auterra Oxidative Desulfurization</td>
<td>sulphur removal</td>
<td>unknown</td>
</tr>
<tr>
<td>Electromechanical based technologies</td>
<td>physical separation</td>
<td>unknown</td>
</tr>
<tr>
<td>Novel Additive-Based Upgrading</td>
<td>various</td>
<td>unknown</td>
</tr>
<tr>
<td>In Situ Upgrading</td>
<td>various</td>
<td>unknown</td>
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There are a range of other partial upgrading technologies which are at early stages of development.
Recommendation for R&D

- Viscosity reduction
  - Alternatives to thermal cracking
- Asphaltene stability
  - Stability, compatibility and fouling propensity
- Olefin reduction
  - Good vs bad olefins
- Asphaltene uses
  - New markets and uses for rejected by-product
- Quality improvement vs price for partially upgraded bitumen
  - Value to refiners of key quality improvements
- TAN reduction
CCQTA Initiatives

• Active CCQTA products that related to the recommended R&D initiatives

• Properties of Thermally Processed Materials (Olefin reduction)

👉 Investigate the properties of materials that have been thermally processed through partial upgrading processes

→ Differentiate between cracked and virgin products

→ Further identify which of those differing properties result in negative impacts to downstream operations
CCQTA Initiatives

• Crude Oil Compatibility Test Method
  ✦ Measurement of stability, compatibility and fouling propensity
  ✦ Applicable to partially upgraded products and blends

• TAN Reduction
  ✦ Long history of developing test methods applicable to partially upgraded materials leading to a published white paper
  ✦ This white paper provides a brief summary of the 14 year history of this project and findings is available on the CCQTA web site
Conclusions

• Partial Upgrading technology developments progressing
• A range of technologies produce a range of products
• Work is necessary to better understand the relationship between product quality and value to the market
• R&D efforts identified with the CCQTA active in projects to better understand the quality impacts on refinery customers
Alberta Innovates Report

Bitumen Partial Upgrading 2018 Whitepaper
AM0401A
Alberta Innovates

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March 2018

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May 24, 2018

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