Summary - Bitumen to Refined Products and Petrochemicals

Prepared for:
Government & Industry Sponsors

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Outline of Discussion Today

- Introduction – Refined Products and Petrochemicals from Bitumen
- Purpose and Objectives
- Upgrading/Refining/Petrochemical Cases
- Summary of Results
- Conclusions
How Much to Upgrade?

Dollars per Barrel

Illustrative

Price of Product

Margin

Direct Cost

Bitumen

Upgraded Light SCO

Refined Products

Petro-Chemicals

Return on Capital?

Marketability?

Degree of Upgrading (eg. API)

Capital Cost
Planned Phase Approach to this Study

- **Phase 1 – Current Focus**
  - Potential for upgrading to refined products and petrochemicals
  - Assess preliminary economics and potential of concept

- **Phase 2 – Deferred to Later**
  - Assess competitive cost of supply of these options
  - Strategies for implementation
Purpose and Objectives of Study

- To quantify the potential and benefits of increasing the upgrading step to produce refined products and petrochemicals
- Target preferred markets for petroleum products considering market size and accessibility (West Coast and Midwest)
- Develop the economic potential of refined products and petrochemicals relative to upgrading to synthetic crude
- Outline merits for such an Alberta development
Scope of Study

- Determine the potential benefit of upgrading bitumen beyond synthetic crude:
  - To produce refined products
  - To produce some petrochemical products

- Based on a minimum of 200,000 B/D of raw bitumen feedstock

- Refined products are gasoline, diesel and jet fuel, focusing on serving the Midwest and California markets. California gasoline and diesel meet CARB specifications.

- Petrochemical products will be priced based on export prices except if there is sufficient volumes to feed a local derivative plant.

- Study premise assumes the new project(s) do not impact market prices.
Potential for Upgrading Bitumen

5 Cases were evaluated, based on combinations of the above blocks.
## Proposed Upgrading/Refining/Petrochemical Cases

<table>
<thead>
<tr>
<th>Case 1</th>
<th>Basic Upgrader Producing SCO</th>
</tr>
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<tbody>
<tr>
<td>Case 2</td>
<td>Similar to Case 1, but Recover Ethane/Ethylene</td>
</tr>
<tr>
<td>Case 3</td>
<td>Add Hydrocracker, Producing Naphtha and Distillates</td>
</tr>
</tbody>
</table>
| Case 4 | Produce Refined Products  
4a. VGO hydrocracking and catalytic reforming  
4b. FCC/alkylation |
| Case 5 | Produce Refined Products and Primary Petrochemicals  
5a. VGO hydrocracking and catalytic reforming, benzene and xylenes recovery with styrene  
5b. DCC/alkylation and propylene recovery |
Potential Refined Products Export Markets

Legend

- Products Pipeline
- Crude &/or NGL Pipeline
- Refining Center
- Other Market

From Gulf Coast

To U.S. Midwest

West Coast
Key Pricing Assumptions

1. Crude Oil and Natural Gas Prices

<table>
<thead>
<tr>
<th></th>
<th>2010 Current U.S. Dollars</th>
<th>2003 Constant Dollars</th>
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<tbody>
<tr>
<td>WTI $/B</td>
<td>26.65</td>
<td>23.20</td>
</tr>
<tr>
<td>Natural Gas (AECO) $/MMBtu</td>
<td>4.00</td>
<td>3.50</td>
</tr>
</tbody>
</table>

2. Currency at $0.75 U.S. equals $1.00 Cdn.

3. Product pipeline tariffs assumed equal to crude oil pipeline tariffs plus new terminalling costs for handling refined products.
Pricing of Refined Products

1. Gasoline – Detroit and Los Angeles less transportation
   - Los Angeles based on CARB prices

2. Diesel and Jet Fuel – Detroit and Los Angeles less transportation
   - Los Angeles diesel based on CARB prices.

3. Naphtha – Diluent price at Edmonton (adjusted relative to condensate)

4. Mixed C3 – Edmonton price to a fractionator

5. Mixed C4 – Edmonton price for sale to a refinery
Pricing of Petrochemical Products

1. Ethylene/ethane – Both sold at ethane price
2. Ethane – price based on recovery from natural gas
3. Propylene – USGC less rail freight costs for small volumes, but based on feeding a polymer plant for large volumes.
4. Benzene – USGC less rail freight costs
5. Styrene – US Midwest less freight; equal to USGC price
6. Xylenes – When not used in gasoline, equal to USGC less rail freight costs
7. Cumene – uneconomic, so not considered.
Product and Light Ends Prices in Edmonton - 2010

U.S. Cents Per Pound - Constant 2003 Dollars

- Styrene: 26.8
- Ethylene: 19.7
- Propylene - Polymer Grade: 16.6
- Xylenes: 11.1
- Ethane: 10.9
- Gasoline (30 ppm S): 9.7
- Propane: 9.4
- Jet Fuel: 8.6
- Natural Gas: 8.3
- Diesel Fuel (15 ppm S): 8.2
- Synthetic Crude Oil: 6.9
- Bitumen: 2.7
Refined Product Netback Prices Above SCO At Edmonton 2015

California market should yield the highest refined product netback when compared to the Midwest market.
Comparison of Capital Costs

Millions of U.S. Dollars (Constant 2003)

- Upgrading
- Refined Products to U.S. Midwest
- Refined Products to California Midwest

Cases:
- Case 1
- Case 3
- Case 4a(1)
- Case 4b(1)
- Case 5a(1)
- Case 5b(1)
- Case 4a(2)
- Case 4b(2)
- Case 5a(2)
- Case 5b(2)
Bitumen Netback Price: Comparison Of Cases

Constant 2003 $US per Barrel

- Midwest Markets: Price of Bitumen Required to Achieve an IRR = 12% (1)
- California Markets: Price of Bitumen Required to Achieve an IRR = 12% (1)

Note 1: For each case, assumes bitumen price is constant throughout the life of the project.
California: Case 5a(2) Sensitivity

- Capital Costs (+/- 30%)
- Bitumen (+/- $1.50/B)
- Products (+/- $2.00/B WTI)
- Natural Gas (+/- 0.40 $/MMBTU)

- IRR

12.6% 14.6% 15.3% 15.7% 16.5% 17.2% 17.2% 16.5% 15.7% 15.3% 14.6% 12.6%

21.0% 19.0% 17.0% 15.0% 13.0% 11.0%

Capital cost is the most sensitive variable.
Incremental IRR Comparison Based on Case 1

SCO Price

- Hydrocracking cases (4a & 5a) show positive returns over base case.
- Addition of styrene to case 5a improves overall economics.
Conclusions

- Good economic value added attributed to refined products and petrochemicals incremental to stand alone upgrading.
- Large capital investment required. Potential to reduce capital costs has a very positive impact on overall economics.
- Large volume of exports to Midwest or California markets based on product pipeline availability.
- Enbridge expansions need to be configured to accommodate refined products.
- Terasen capability to ship products contingent on major expansion to ship crude oil.
- Californian market should provide superior returns as compared to U.S. Midwest.
Recommendations for Further Study

- Selection of a likely business case should be made.
- Logistical options need to be further developed.
- Potential Market Barriers
  - Introduction of large supply into market may result in price discounting.
- Competitiveness of Alberta Based Projects
  - Need to examine staging of project to manage capital cost.
- Impact on Alberta Industry
- Synergies with other Projects Should be Explored
  - Procurement of third party fuel/hydrogen could reduce capital cost exposure
  - Extraction of propylene & styrene in combination with existing operations could help to improve economics
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