Ultra-Heavy Oil Production and Upgrading with Gasification

Gasification Technologies 2004

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GE Energy
Oil Sands Reserves
Source: Overview of Canada’s Oil Sands, TD Securities 2002

Majority of New Production (steam inj required)
Orinoco Reserves

1.2 trillion bbls oil in place
All In Situ production
# Heavy Oil Reserves


<table>
<thead>
<tr>
<th></th>
<th>Oil Sands</th>
<th>Orinoco</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Alberta, Canada</td>
<td>Eastern, Venezuela</td>
</tr>
<tr>
<td>Crude API</td>
<td>8-10</td>
<td>8-10</td>
</tr>
<tr>
<td>Crude Sulfur, wt%</td>
<td>2-4%</td>
<td>3.5%</td>
</tr>
<tr>
<td>Oil in Place (OIP)</td>
<td>2.2 trillion bbl</td>
<td>1.2 trillion bbl</td>
</tr>
<tr>
<td>Ultimate Recovery, %</td>
<td>20-50%</td>
<td>20-50%</td>
</tr>
<tr>
<td>US&amp;Canada Crude Supply*</td>
<td>55-135 years</td>
<td>30-75 years</td>
</tr>
</tbody>
</table>

* At 2001 US and Canada consumption rate of 21 million bbl/d.
Heavy Oil Production

Steam Assisted Gravity Drainage (SAGD)
- 2 horizontal wells – 1 steam inj/1 oil+water production
- Steam/oil ratio 2 (min), 2.5 (ave)
- Recovery factor 50-75%
- Applied in vertically permeable, thicker deposits

Cyclic Steam Stimulation (CSS)
- 1 well in alternating steam inj/oil+water production
- Steam/oil ratio 4 (ave)
- Recovery factor 25-30%
- Applied in horizontally permeable, thinner deposits
Cold Lake Cyclic Steam Stimulation (CSS)

Operating Statistics

- Active wells: 3700
- Production: 120-140 kbd
- Steam capacity: 600 kbd
- Water re-use: 95%
- Gas consumption: 195 Mcfd
- Electricity generation: 170 MW

Source: Imperial Oil Investor Meeting Dec 2003
Heavy Oil Upgrader – Potential Market

Number of 100 MBD Upgraders

- **Canada***: Over 100 year overall field life
- **Venezuela**: Over 50 year overall field life
- **Other***: 10-20 year overall field life

* Based on 2.2 trillion bbl OIP @ 20- 50% recovery and 20 year upgrader life
** Based on 1.2 trillion bbl OIP @ 20-50% recovery and 20 year upgrader life
*** Mexico, North Sea, China
Upgrader Crude Product Options

Source: Overview of Canada’s Oil Sands, TD Securities 2002

<table>
<thead>
<tr>
<th></th>
<th>WTI</th>
<th>Synthetic Crude</th>
<th>Bitumen Blend</th>
<th>Bitumen</th>
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</thead>
<tbody>
<tr>
<td>Gravity, API</td>
<td>40</td>
<td>29-36</td>
<td>20-21</td>
<td>8-10</td>
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<tr>
<td>Viscosity, csT</td>
<td>5</td>
<td>3</td>
<td>325</td>
<td>1,000,000</td>
</tr>
<tr>
<td>Sulfur, %</td>
<td>&lt;0.5%</td>
<td>&lt;0.5%</td>
<td>2-4%</td>
<td>2-4%</td>
</tr>
<tr>
<td>Price ($/bbl)</td>
<td>$20</td>
<td>$18-21</td>
<td>$12-16</td>
<td>$9-14</td>
</tr>
</tbody>
</table>
Syncrude Upgrader Cost Overrun
Source: Canadian Oil Sands Trust News Release April 2002, March 2004

Capital Cost ($ billions)*

- Approved
- 2002 Est
- 2004 Est

$3.7 billion Cost overrun
8 month delay

* Investment for Stage 3 (110 MBD upgrader capacity increase and syncrude quality increase-startup 2006)
Ultra-Heavy Crude Production Diluent Blending

Supplemental Gas (as req’d)
100 MMSCFD Nat Gas
1 MSCF/bbl

Condensate Diluent
API 57
30 MBD

Injected Steam
2 bbl Stm/bbl Crude
2830 kpph

Syncrude
130 MBD
20 API

100 MBD Crude
8.6 API

Boiler

100 MBD
20 API
Ultra-Heavy Crude Production Coker Based Upgrader

Crude 8.6 API + 55 API = 35 MBD Crude+Dil

- Crude 8.6 API + 55 API = 100 MBD
- Diluent 55 API = 33 MBD

- Diluent 8 MBD
- Nap+Kero 4%
- Diesel 9%
- Gas Oil 33%
- Parafinic Resid 30%
- Asphaltenes 24%

- Crude Sep
- 15 MBD 2 API
- Coker
- Light Dist 2 MBD
- Fuel Gas
- Acid Gas Removal
- H2 50 MMSCFD
- Sour Gas
- SMR

- Gas Oil Hydrocracker
- Diluent 25 MBD 55 API

- Syncrude 20 API 73 MBD Crude 25 MBD Dil

- Asphaltenes 24%
- Parafinic Resid 30%
- Diesel 9%
- Gas Oil 33%
- Nap+Kero 4%

- Ultra-Heavy Crude Production Coker Based Upgrader

- Syncrude 20 API
- 73 MBD Crude
- 25 MBD Dil

- Coke 1250 TPD

- Acid Gas to Injection (85 TPD S)
Coker Upgrader - Integration

Fuel Gas Balance
- Crude sep, coker, and hydrocracker require fuel gas heaters
- Supplemental nat gas required for SMR
- Remote boiler or combustion turbine operation on nat gas

Sour gas treating and hydrogen purification
- Common system for coker and hydrocracker sour gas
- Sweet fuel gas consumed in upgrader heaters

Reliability and Flexibility
- Hydrogen production reliability – nat gas fueled
- Steam/oil ratio flexibility – nat gas fueled
- Crude diluent storage
Ultra-Heavy Crude Production Gasification Based Upgrading & Fuel Gas Production

- Crude: 8.6 API, 100 MBD
- Diluent: 57 API, 29 MBD
- 45 MBD Crude+Dil

Crude Sep:
- Diluent 10 MBD
- Nap+Kero 4%
- Diesel 9%
- Gas Oil 33%
- Paraffinic Resid 30%
- Asphaltenes 24%

Air Sep: Oxygen 3500 TPD

Gasification:
- ACID GAS REMOVAL
- CO2 to EOR/Injection (5000 TPD)

Hydrogen: 40 MMSCFD

Gas Oil Hydrocracker:
- Sour Gas
- Fuel Gas 100 MMSCFD Nat Gas Equiv
- Acid Gas to Injection (170 TPD S)

Syncrude: 20 API, 65 MBD Crude
- 19 MBD Dil

18 MBD Diluent: 57 API

15 MBD 17 API

Crude Sep: 19 MBD 2 API

19 MBD 17 API

Diluent: 29 MBD
Gasification Upgrader - Integration

Gasification byproduct heat utilization
- Air separation compressor drives
- Oil heating
- Remote boiler or combustion turbine operation

Sour gas treating and hydrogen purification
- Common system for syngas and hydrocracker gas
- Common acid gas reinjection and CO2 recovery/reinjection

Reliability and Flexibility
- Hydrogen production redundancy
- Steam/oil ratio flexibility
- Backup and supplemental fuel (nat gas or distillate)
- Crude diluent storage
# Upgrader Feed and Product Summary

<table>
<thead>
<tr>
<th>Feeds</th>
<th>Diluent</th>
<th>Coker</th>
<th>Gasifier</th>
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</thead>
<tbody>
<tr>
<td>Crude (8-10API), MBD</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Power, MW*</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Nat Gas, MMSCFD</td>
<td>100</td>
<td>125</td>
<td>0</td>
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<tr>
<td>Diluent, MBD</td>
<td>30</td>
<td>0</td>
<td>0</td>
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</table>

<table>
<thead>
<tr>
<th>Products</th>
<th>Diluent</th>
<th>Coker</th>
<th>Gasifier</th>
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<tbody>
<tr>
<td>Syncrude (20 API) MBD</td>
<td>130</td>
<td>98</td>
<td>84</td>
</tr>
<tr>
<td>Coke, sTPD</td>
<td>0</td>
<td>1250</td>
<td>0</td>
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<tr>
<td>CO2, sTPD</td>
<td>0</td>
<td>0</td>
<td>5000**</td>
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</tbody>
</table>

*Internal power supplied by cogen

** At 50% CO2 recovery
Emissions Comparison
Source: SFA Pacific 2002, CERA 2004

Based on combustion turbine/boiler equipped with SCR, and coke boiler with wet FGD (98% SO2 reduction).

Spent limestone/FGD scrubber sludge disposal required
Oil Sands Upgrader - Capital Cost

Capital Cost ($ millions 2004)

- 20 API Bit Blend
- 100 MBD 27% Upgrader
- 100 MBD 34% Upgrader
- 72 MBD 100% Upgrader

*Source: OptiCanada March 15, 2004 news release (estimated Oil production/upgrader split).
Upgrader Production Cost

Syncrude (20 API) Price $/bbl

*Based on WTI @ $30/bbl, delivered gas price of $5.00/MSCF, and 100 MBD crude production.
Gasification is the Key to Unlocking the Upgrader Technology Potential

- Eliminate Diluent Dependency
- Minimal Environmental Impact
- Eliminate the Natural Gas Habit
- Long Term Sustainablility
  - Energy efficient bottoms utilization
  - Cogen Export Power Option
GE Upgrader Offering

- License Gasification Technology
- Power and Steam Block Equipment Supply
- Gasification Integration Expertise
  - Air Separation
  - Acid Gas Removal
  - Sulfur Recovery
  - Hydrogen Purification and Recycle
### GE IGCC Power Island Leadership

<table>
<thead>
<tr>
<th>Customer</th>
<th>Type</th>
<th>MW</th>
<th>Syngas Start Date</th>
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<tbody>
<tr>
<td>Cool Water</td>
<td>107E</td>
<td>120</td>
<td>5/84</td>
</tr>
<tr>
<td>PSI</td>
<td>7FA</td>
<td>262</td>
<td>11/95</td>
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<tr>
<td>Tampa</td>
<td>107FA</td>
<td>250</td>
<td>9/96</td>
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<tr>
<td>Texaco El Dorado</td>
<td>6B</td>
<td>40</td>
<td>9/96</td>
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<tr>
<td>Sierra Pacific</td>
<td>106FA</td>
<td>100</td>
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<tr>
<td>SUV Vresova</td>
<td>209E</td>
<td>350</td>
<td>12/96</td>
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<tr>
<td>Schwarze Pumpe</td>
<td>6B</td>
<td>40</td>
<td>9/96</td>
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<tr>
<td>Shell Pernis</td>
<td>2x6B</td>
<td>80</td>
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<tr>
<td>ISE / ILVA</td>
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<td>Motiva Delaware</td>
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<td>Sarlux</td>
<td>3x109E</td>
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<tr>
<td>Piombino</td>
<td>109E</td>
<td>150</td>
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<td>Exxon Singapore</td>
<td>2x6FA</td>
<td>180</td>
<td>3/01</td>
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</table>

Over 600,000 Hours on Syngas
# GE Gasification Technology

## Commercial Operation – Liquid Feeds

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>FEEDSTOCK</th>
<th>END PRODUCT</th>
<th>STARTUP</th>
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<tbody>
<tr>
<td>1. JAPAN</td>
<td>CRUDE OIL</td>
<td>CARBON MONOXIDE (CO)</td>
<td>1961</td>
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<tr>
<td>2. GERMANY</td>
<td>HEAVY FUEL OIL</td>
<td>OXOCHEMICALS</td>
<td>1966</td>
</tr>
<tr>
<td>3. GERMANY</td>
<td>VACUUM RESIDUE</td>
<td>METHANOL</td>
<td>1974</td>
</tr>
<tr>
<td>4. JAPAN</td>
<td>VACUUM RESIDUE</td>
<td>METHANOL</td>
<td>1980</td>
</tr>
<tr>
<td>5. INDIA</td>
<td>HEAVY FUEL OIL</td>
<td>AMMONIA</td>
<td>1981</td>
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<tr>
<td>6. P. R. OF CHINA</td>
<td>VACUUM RESIDUE</td>
<td>AMMONIA</td>
<td>1983</td>
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<td>7. TAIWAN</td>
<td>VACUUM RESIDUE</td>
<td>ACETIC ACID</td>
<td>1984</td>
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<td>8. USA</td>
<td>VACUUM RESIDUE, H-OIL BOTTOMS</td>
<td>HYDROGEN</td>
<td>1984</td>
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<tr>
<td>9. P.R. OF CHINA</td>
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<td>12. P. R. OF CHINA</td>
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<td>13. P. R. OF CHINA</td>
<td>HEAVY FUEL OIL</td>
<td>OXOCHEMICALS</td>
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<td>14. P. R. OF CHINA</td>
<td>HEAVY RESIDUE</td>
<td>AMMONIA</td>
<td>1995</td>
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<tr>
<td>15. GERMANY</td>
<td>VISBREAKER TAR</td>
<td>METHANOL</td>
<td>2000</td>
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<td>16. USA</td>
<td>DEASPHALTER RESIDUE</td>
<td>SYNTHESIS GAS</td>
<td>2000</td>
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<td>17. SINGAPORE</td>
<td>HEAVY FUEL OIL</td>
<td>CO &amp; HYDROGEN</td>
<td>2000</td>
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<tr>
<td>18. ITALY</td>
<td>ASPHALT</td>
<td>POWER &amp; STEAM</td>
<td>2001</td>
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<tr>
<td>19. ITALY</td>
<td>VISBREAKER TAR</td>
<td>POWER STEAM &amp; HYDROGEN</td>
<td>2001</td>
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<tr>
<td>20. SINGAPORE</td>
<td>ETHYLENE STEAM CRACKED TAR</td>
<td>POWER &amp; STEAM</td>
<td>2001</td>
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<tr>
<td>21. ITALY</td>
<td>VISBREAKER TAR</td>
<td>POWER &amp; STEAM</td>
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<td>22. P. R. OF CHINA</td>
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