Canadian Oil Sands: Development and Future Outlook

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WWW.AERI.AB.CA
Conventional vs. Unconventional Resources

- Conventional Oil & gas
  - 952 billion bbls

- Bitumen
  - USGS 5.6 Trillion bbls discovered
  - 900 billion bbls

- Heavy Oil
- Extra Heavy

- Oil Shale

- CBM
- Tight Gas
- Shale Gas
- Deep Gas
- Gas Hydrate

Increased Costs
Improved Technology

Canadian Oil Sands - Huge Resources

Canadian vs. World Oil Resources

(billion m³)

Canada

World

- Conventional
- Heavy Oil
- Bitumen

Alberta, Canada

Athabasca

Peace River

Wabasca

Cold Lake

Edmonton

Calgary
Proven World Reserves

Sources: Oil and Gas Journal – Dec 2002, AEUB
How Much will Non-conventional Oil Contribute?

World-Oil Production
Non-conventional oil emerges as a major new source

mb/d


OPEC  Non-OPEC  Non-conventional oil

World Liquids Production Outlook

- Liquids Demand
- OPEC
- Canadian Oil Sands
- NGLs, OPEC Condensate, Other
- Non-OPEC Crude + Condensate
Three locations:
- Peace River
- Athabasca
- Cold Lake

**Canada’s Oil Sands**

- **Reserves (2003 - EUB)**
  
<table>
<thead>
<tr>
<th></th>
<th>Oil Sands</th>
<th>Conv.</th>
</tr>
</thead>
<tbody>
<tr>
<td>In Place</td>
<td>1,629</td>
<td>62</td>
</tr>
<tr>
<td>Remaining Est.</td>
<td>175</td>
<td>2</td>
</tr>
<tr>
<td>Rem. Ult. Pot'l</td>
<td>310</td>
<td>5</td>
</tr>
</tbody>
</table>
The Nature of the Oil Sands Resource

- In situ Area
- Mineable Area
- Intermediate In situ
- Open Pit Mine
- Oil Sands Zone
- Limestone

- Steam Injection
- Oil Recovery
- > 200 metres
- 75-200 metres
- < 75 metres
Oil Sands

What is special?

Bitumen

Water

~10 nm thick

Quartz or Clay Mineral

Sand Grain

Fines Cluster

Bitumen
“Technology Oil “
Continuous Innovation Since the 1930’s

From Oil Sands → To Bitumen → to Synthetic Crude Oil
Producing Bitumen - Surface Mining

![Temperature (°C) vs. Viscosity (cP) Graph for Cold Lake and Athabasca](image-url)

- **Temperature (°C)**: 0, 100, 200, 300, 400
- **Viscosity (cP)**: 1, 10, 100, 1,000, 10,000, 100,000, 1,000,000, 10,000,000

Lines represent:
- **Red**: Cold Lake
- **Blue**: Athabasca

**Surface Mining**

AERI
Innovation in Mining Technology
From Draglines to Shovel & Truck Operations
400 tonne Ore Trucks
Slurry Hydrotransport - Remote Mine
(Separation during flow)
Mining Extraction to Produce Bitumen

**Mining**
- Draglines, Bucketwheels & Conveyor Systems
- Truck & Shovel Feed System
- Hydrotransport System

**Extraction**
- Oil Sand
- Oil Sand Slurry
- Tumblers
- Primary Separation Vessel
- Froth Treatment

**Upgrading**
### Mining Projects - Who is playing the game

<table>
<thead>
<tr>
<th>Year</th>
<th>Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>Suncor, Syncrude</td>
</tr>
<tr>
<td>2000</td>
<td>Suncor, Syncrude</td>
</tr>
<tr>
<td>2005+</td>
<td>Suncor, Syncrude, Albian/Shell</td>
</tr>
<tr>
<td></td>
<td>CNRL, Imperial, Synenco, Fort Hills</td>
</tr>
</tbody>
</table>

*Not an all inclusive list*
Producing Bitumen - In Situ

- Cold Lake
- Athabasca

Viscosity (cP)
- 10,000,000
- 1,000,000
- 100,000
- 10,000
- 1,000
- 100
- 10
- 1

Temperature (C)
- 0
- 100
- 200
- 300
- 400

Surface Mining

In Situ
In Situ Production Technology
Cyclic Steam Stimulation Process

Stage 1: Steam Injection
Steam injected into the reservoir

Stage 2: Soak Phase
Steam and condensed water heat the viscous oil

Stage 3: Production
Heated oil and water are pumped to the surface
Drilling Technology Minimizes Land Disturbance

Imperial Oil Cold Lake - Cyclic Steam Project 125,000 bbl/day
Gravity Drainage Concept
(SAGD Process)

Steam Chamber Development

Temperature (°C)

Courtesy: David Law, Alberta Research Council
In Situ *Projects* - *Who is playing the game?*

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<th>1980</th>
<th>2000</th>
<th>2005+</th>
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<tr>
<td>Imperial</td>
<td>Imperial AEC CNRL Shell PanCdn Numac Northstar Murphy</td>
<td>Imperial JACOS Encana Deer Creek CNRL OPTI/Nexen Shell BlackRock Suncor ConocoPhillips PetroCanada Husky Petrovera Total Devon</td>
</tr>
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*Not an all inclusive list*
Upgrading Technology - 1940 - Today

Thermal Cracking

Visbreaking
Hydrogen Addition
Coking

Deasphalting

Gasification

Heat  H₂

Shell/Albian
Opti-Nexen

Suncor
Syncrude
Husky
CNRL

After Murray Gray, University of Alberta
Integrating In-Situ Oil Sands Production and Upgrading to Reduce Cost and Increase Product Value

OPTI – Nexen Long Lake Project

- SAGD
  - Bitumen
  - Oil sands
- OrCrude process
  - Asphaltenes
- Hydro-cracking
  - Hydrogen
  - Premium synthetic crude
- Shell Gasification Process
  - Fuel gas
  - Steam
**Synthetic Crude Oil – desirable features**

Conventional Light Sweet Crude
- Sulfur 150 - 300 wppm
- Sulfur 0.16 wt%
- Aromatics 20-25% LV
- Sulfur 0.4 - 0.6 wt%
- Sulfur 1.4 - 1.8 wt%

Synthetic Sweet Blend
- Sulfur 2 wppm
- Sulfur 0.028 wt%
- Aromatics 34% LV
- Sulfur 0.29 wt%

- Lower S
- More Distillate
- Lower S
- More VGO
- Lower S
- No Residue
## Current Production Costs

<table>
<thead>
<tr>
<th>Production Method</th>
<th>Crude Type</th>
<th>Cost per barrel (US$, 2003)</th>
<th>Operating</th>
<th>Supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mining/Extraction</td>
<td>Bitumen</td>
<td>5 to 8</td>
<td>10 to 13</td>
<td></td>
</tr>
<tr>
<td>Cold Production</td>
<td>Heavy Oil</td>
<td>5 to 7</td>
<td>10 to 13</td>
<td></td>
</tr>
<tr>
<td>Cyclic Steam Stimulation (CSS)</td>
<td>Bitumen</td>
<td>6 to 11</td>
<td>10 to 15</td>
<td></td>
</tr>
<tr>
<td>Steam Assisted Gravity Drainage</td>
<td>Bitumen</td>
<td>6 to 12</td>
<td>9 to 14</td>
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<tr>
<td>Mining/Upgrading</td>
<td>Synthetic</td>
<td>10 to 14</td>
<td>18 to 23</td>
<td></td>
</tr>
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</table>

*Source: National Energy Board of Canada*
Economic Returns - In Situ and Mining Projects

In Situ: WTI at $US 28, $US 11.5 differential

Mining/Upgrading: WTI at $US 28

Gas Price, $US per MMBtu
Western Canada Sedimentary Basin Crude Oil Production Potential

- $US20 Billion under construction or approved
- $50 Billion additional announced
- ~70% of Canada’s production by 2020
Gateway Project
1200 km, 30 in dia line
Capacity 400,000 bpd

Existing and Expanded Markets

Far East Markets
5a

California Markets
5b

1-5 are New Markets

Refineries
★ Canadian Supplied
★ Not Canadian Supplied

Enbridge: New Market Access Plan
Potential Markets - US West Coast & Far East

Sea transport from Prince Rupert is the same distance to Asia as the Middle East.
Major Challenges
Need for Technological Innovation

- Natural gas substitution
  - Rising cost and future availability of natural gas
    - Steam generation
    - Hydrogen for upgrading
- Improved recovery processes
  - Significant portion of resource not currently economic
- Improved refinery conversion technologies
  - Future fuel requirements & refinery fit
- Air emissions, land access and water management
  - Land disturbance / reclamation costs
  - Manage water demands
- High GHG emissions add significant risks
Summary

- Canadian oil sands resources are immense
- Serious challenges remain
  - technical, environmental, human resource, infrastructure, costs and required investments
- Innovation is key to “technology oil”
  - Production is expected to reach 3 MM bbls/d before 2020 (currently 1 MM bbls/d)
  - As production increases, more upgrading will be required to meet refinery specifications and increase value
  - Future co-production of clean fuels and Petrochemicals - technically and economically feasible
- Even this aggressive development can supply only some 10 - 15% of the required new global oil demand
Summary

- “Integrated Energy Economy” is key to a secure energy future
  - Significant opportunities emerge when we consider the energy sector as an interconnected whole

- The Energy Innovation Network (www.EnergyINet.com) designed to take advantage of the shift in energy systems
  - From conventional to unconventional oil & gas
  - From coal burning to advances in near-emission free clean coal technology
  - From a relatively low to significantly high mix of renewable and hydrogen energy options
  - From a focus on separate energy sources to an integrated energy system