Canadian Oil Sands: Development and Future Outlook

National Academies Workshop on Trends in Oil Supply/Demand and Peaking of Conventional Oil Production

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

- **Conventional Oil & gas**
- **Heavy Oil**
- **Extra Heavy**
- **Bitumen**
- **Oil Shale**
- **CBM**
- **Tight Gas**
- **Shale Gas**
- **Deep Gas**
- **Gas Hydrate**

Advanced Technology
Increased Costs
Market Price Sensitivity
Environmental Concerns

952 billion bbls
900 billion bbls

USGS 5.6 Trillion bbls discovered

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

Canadian Oil Sands - Huge Resources

Canadian vs. World Oil Resources

(billion m³)

Canada

World

Conventional
Heavy Oil
Bitumen

Wightman (1997)

Alberta, Canada

Athabasca
Peace River
Wabasca
Cold Lake
Edmonton
Calgary

Fort McMurray
Canada’s Oil Sands

Three locations:
- Peace River
- Athabasca
- Cold Lake

Reserves (2003 - EUB)
(Billion Barrels)

<table>
<thead>
<tr>
<th></th>
<th>Oil Sands</th>
<th>Conv.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil-in-place</td>
<td>1,629</td>
<td>62</td>
</tr>
<tr>
<td>Est. Reserves</td>
<td>175</td>
<td>2</td>
</tr>
<tr>
<td>Rem. Ult. Pot’l</td>
<td>310</td>
<td>5</td>
</tr>
</tbody>
</table>
Proven World Oil Reserves

Source: Oil & Gas J, December 2004
The Nature of the Oil Sands Resource

<table>
<thead>
<tr>
<th>Production Technology</th>
<th>Reserves</th>
<th>2004 Production, bbls/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mining</td>
<td>19%</td>
<td>610,959</td>
</tr>
<tr>
<td>In Situ</td>
<td>81%</td>
<td>386,164</td>
</tr>
</tbody>
</table>
Oil Sands - What is special?

- Bitumen
- Water
- Quartz or Clay Mineral
- Sand Grain
- Fines Cluster

Bitumen ~10 nm thick
“Technology Oil”
Continuous Innovation Since the 1930’s

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

The graph shows the relationship between temperature (C) and viscosity (cP) for two different locations: Cold Lake and Athabasca. The viscosity decreases sharply as temperature increases, indicating a significant reduction in bitumen's viscosity at higher temperatures.

Key observations:
- **Viscosity (cP):** The viscosity values range from 1 to 10,000,000 cP.
- **Temperature (C):** The temperature range is from 0 to 400 degrees Celsius.
- **Cold Lake:** The red line indicates the viscosity profile for Cold Lake, showing a steeper decrease in viscosity compared to Athabasca.
- **Athabasca:** The blue line represents the viscosity profile for Athabasca, with a less steep decrease in viscosity compared to Cold Lake.

The graph highlights the importance of temperature in reducing bitumen viscosity, which is critical for its transportation and processing.
Innovation in Mining Technology
From Draglines to Shovel & Truck Operations

1970

2000
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**
- (lots of $H_2$)
Mining *Projects* - Who is playing the game?

<table>
<thead>
<tr>
<th>1980</th>
<th>2000</th>
<th>2005+</th>
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<tbody>
<tr>
<td>Suncor</td>
<td>Suncor</td>
<td>Suncor</td>
</tr>
<tr>
<td>Syncrude</td>
<td>Syncrude</td>
<td>Syncrude</td>
</tr>
</tbody>
</table>

Not an all inclusive list

Albian/ Shell
CNRL
Imperial
Synenco
Fort Hills
Producing Bitumen - In Situ

![Graph showing viscosity (cP) vs. temperature (°C) for Cold Lake and Athabasca bitumens, indicating lower temperatures for in situ production compared to surface mining.](image)

- Cold Lake
- Athabasca
Transporting Steam Generators - Radiant Section

Courtesy of Mark E. Doig
Steam Generator - Burner Flame

Courtesy of Mark E. Doig
Central Plant Under Construction

Courtesy of Mark E. Doig
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
Steam Assisted Gravity Drainage (SAGD) - Schematic

- Horizontal drilling
- Moderate pressure steam (500 psi)
- 50% - 70% oil in place recovery

Courtesy Neil Edmunds, EnCana
Gravity Drainage Concept
(SAGD Process)

Steam Chamber Development

Temperature (°C)

Injector
Producer

Courtesy: David Law, Alberta Research Council
Steam Assisted Gravity Drainage Wells

Source: Suncor
### In Situ Projects - Who is playing the game?

<table>
<thead>
<tr>
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<th>2005+</th>
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<tbody>
<tr>
<td>Imperial</td>
<td>Imperial</td>
<td>Imperial</td>
</tr>
<tr>
<td>Numerous</td>
<td>AEC</td>
<td>JACOS</td>
</tr>
<tr>
<td>Experimental</td>
<td>CNRL</td>
<td>EnCana</td>
</tr>
<tr>
<td>Projects</td>
<td>Shell</td>
<td>Deer Creek</td>
</tr>
<tr>
<td></td>
<td>PanCdn</td>
<td>CNRL</td>
</tr>
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<td></td>
<td>Numac</td>
<td>OPTI/Nexen</td>
</tr>
<tr>
<td></td>
<td>Northstar</td>
<td>Shell</td>
</tr>
<tr>
<td></td>
<td>Murphy</td>
<td>BlackRock</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Suncor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ConocoPhillips</td>
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<td></td>
<td></td>
<td>PetroCanada</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Husky</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MEG/CNPC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Devon</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
</tr>
</tbody>
</table>

*Not an all inclusive list*
Upgrading Technology - 1940 - Today

- Thermal Cracking
  - Visbreaking
  - Hydrogen Addition
  - Coking
    - Deasphalting
      - Gasification
        - Steam
        - H₂
    - Suncor
    - Syncrude
    - Husky
    - CNRL

After Murray Gray, University of Alberta
**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%

**Features**
- Lower S
- More Distillate
- Lower S
- More VGO
- Lower S
- No Residue

**Synthetic Crude Oil - desirable features**
Oil Sands Hydrogen Demand Scenarios

Source: Canadian Hydrogen. Current Status and Future Prospects, Dalcor Consultants & Intuit Strategies, August 2004
What the Future may look like

Integrated Energy Industry, Diversified Products, Broad Markets

Hydrogen and steam
From Coke, Coal, Bitumen Residue
Gasification

Natural Gas & NGLs

steam

H₂

Bitumen

Petrochemical Feedstocks

Synthetic Crude Oil

Power Plants

Clean Power

Homes & Businesses

Primary Petrochemicals

Planes, Trains & Automobiles

Clean Transportation Fuels

Value added Products

Resins and Plastics

Fibres and Materials

Film and Packaging

Adhesives and Composite Products

Fertilizers

Film and Packaging

Adhesives and Composite Products

Fertilizers
Integrating In-Situ Oil Sands Production and Upgrading to Reduce Cost and Increase Product Value

OPTI – Nexen Long Lake Project

- **SAGD**
  - **Bitumen**
  - **Oil sands**
  - **Fuel gas**
  - **Steam**

- **OrCrude process**
  - **Asphaltenes**
  - **Sour synthetic crude**

- **Hydro-cracking**
  - **Premium synthetic crude**
  - **Hydrogen**

- **Shell Gasification Process**
Gasification Capital Cost Payout - SAGD with an upgrader project

Adjusted for 17% volume shrinkage

Source: FirstEnergy Capital
## Oil Sands Production Costs

<table>
<thead>
<tr>
<th>Production Method</th>
<th>Crude Type</th>
<th>Operating</th>
<th>Supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bitumen</td>
<td></td>
<td>5 to 8</td>
<td>10 to 13</td>
</tr>
<tr>
<td>Mining/Extraction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cyclic Steam Stimulation (CSS)</td>
<td>Bitumen</td>
<td>6 to 11</td>
<td>10 to 15</td>
</tr>
<tr>
<td>Steam Assisted Gravity Drainage (SAGD)</td>
<td>Bitumen</td>
<td>6 to 12</td>
<td>9 to 14</td>
</tr>
<tr>
<td>Mining/Upgrading</td>
<td>Synthetic</td>
<td>10 to 14</td>
<td>18 to 23</td>
</tr>
<tr>
<td>Synthetic</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Source: National Energy Board of Canada*
Oil Sands Production Potential

- $US20 Billion under construction or approved
- $50 Billion additional announced
- ~ 70% of Canada’s production by 2020

Numbers Up
Crude oil production from Canadian oil sands has increased significantly in recent years and is expected to continue to do so.

 Millions of barrels per day

- '67: 0.5
- '75: 2.0
- '85: 2.5
- '95: 3.0
- '05: 2.7 million
- '15: 2,000

SOURCE: Canadian Association of Petroleum Producers
THE WASHINGTON POST
What About Transportation?
Expanded Markets to Sustain Growth

Gateway Project
Capacity 400,000 bpd

Far East Markets
5a

California Markets
5b

Refineries
★ Canadian Supplied
★ Not Canadian Supplied

Enbridge: New Market Access Plan
Sea transport from Kitimat - similar distance to Asia as the Middle East

Potential Markets - US West Coast & Far East
Summary

- Canadian oil sands resources are immense
- Serious challenges remain
  - Technical – hard to extract and sensitive to market and input costs
  - Environmental – land, water, emissions (including CO$_2$)
  - Social – community growth, native population
  - Human resource – maintaining a skilled labor force
- 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