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Unlocking the planet’s heavy oil and bitumen resources – A look at SAGD

Subodh Gupta
EnCana Corporation
March, 2005

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A Power Hungry World!

Source: UN Population Division, Energy Information Administration
Predictions based on Hubbert’s theory suggest declining conventional oil supply

Much debate about exact time of the peak

Source: Duncan and Youngquist, Campbell and Laherrerre
Plenty of Fossil Fuel!

- Total fossil fuel over 100 times the conventional oil
- More unconventional oil than conventional

## Enormous Potential

<table>
<thead>
<tr>
<th>Country</th>
<th>Heavy oil / bitumen in place (trillion bbls)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>1.6</td>
</tr>
<tr>
<td>Venezuela</td>
<td>1.2</td>
</tr>
<tr>
<td>FSU</td>
<td>0.2 - 2.5</td>
</tr>
</tbody>
</table>

Source: AEUB, CAPP, EIA, AOSTRA, UNITAR
Consequence of being unconventional

Light vs. Heavy

- More difficult to recover
- Requires more downstream processing
The Downstream Challenge

Upgrading process

Differential
5 – 10 $US/bbl
How to produce this stuff
The Upstream Challenge

Cost of Production

US$/bbl

Canadian Oilsands
Venezuelan Heavy-oil
Middle East
Conventional

Not easy to recover

In situ viscosity
- Canadian Oilsands: > 1e6 cP
- Venezuelan Heavy oil: ~3-10e3 cP

Technology and economics constantly improving
- Oilsands context

Source: based on DOE report 2050(draft)
Canadian Oil Sands: Recovery Technologies

- Surface Mining
- In Situ
  - CSS
  - SAGD

Alberta
- Athabasca deposit 213 billion m$^3$
- Peace River deposit 25 billion m$^3$
- Cold Lake deposit 32 billion m$^3$
Three-Step Process
- Mine Oilsands
- Separate Oil from Sand
  - Washing with Hot Water
- Upgrade the Extracted Oil to Synthetic Crude
Surface Mining

- **Major projects**
  - **Current**
    - Suncor’s mining operations
    - Syncrude’s mining operations
    - Athabasca Oil Sands Project
  - **Upcoming**
    - Kearl Mine, Horizon, Northern Lights and Fort Hills
  - **Current Production Capacity** ~650kbd
  - Announced projects to increase to >1million b/d in 10 years

- **Issues to consider**
  - Economics is location (depth < 75m) dependent
    - Only 5 to 10% reserves suitable
  - Scale of economy requires huge capital
In Situ Processes
Cyclic Steam Stimulation

- Major projects/operators
  - Cold Lake - Imperial
  - Primrose – CNRL

- Advantage
  - Lower surface disturbance
  - Less sensitive to shale barriers

- Issues to consider
  - Recovery ~25-30%
Steam Assisted Gravity Drainage (SAGD)

Advantage
- Lower surface disturbance
- Lower SOR: 2.5 to 3.5
- Economic recoveries ~ 65%
- Modular capital requirements
SAGD
Current and upcoming projects tell the story

- **Current Major Projects**
  - Foster Creek (Encana)
  - Christina Lake (Encana)
  - Mackay River (PetroCanada)
  - Firebag (Suncor)
  - Primrose/Wolflake (CNRL)
  - Hangingstone (JACOS)

- **Upcoming Projects**
  - Joslyn Creek (Deer Creek)
  - Surmont (ConocoPhillips/TFE)
  - Long Lake (Nexen/OPTI)
  - Tucker Lake (Husky)
  - Sunrise (Husky)
  - Jackfish (Devon Energy)
  - Orion (BlackRock)

Source: based on DOB, Jan. 2005, ADOE
SAGD requires steam
steam = fuel and water

- Energy efficiency (GJ/bbl)
  - Heat is an expensive input

- Water usage
  - Water recycle adds to the cost

- Emissions
It costs to heat

Use cheaper fuel
- Bitumen/Residue to substitute Gas
  - Nexen/OPTI
- Other talked-about alternatives
  - Heavyoil/Coke/Coal/Nuclear

Reduce heat requirement
- Process Improvement
  (Also reduces water requirement)
  - Low Pressure Operation
  - Use of Solvents
  - SAP (SAGD + solvent)
Low Pressure SAGD Operation

Effect of Pressure on SOR and Rate

25mx7D reservoir

Issues
- artificial lift
- role of solution gas

Source: Edmunds and Chhina, JCPT, Dec. 2001
What role can solvents play? ..SAP
Enhanced Gravity Drainage in SAP

\[ Q = \sqrt{\frac{2 \cdot \phi \cdot \Delta S_o \cdot K \cdot g \cdot \alpha \cdot h}{m \cdot v_s}} \]

\[ Q \propto \sqrt{\frac{1}{\mu}} \]

steam + solvent + condensed solvent + oil + water
Expected Production with Combining Solvent with SAGD

Expected SAP Benefits (example)

<table>
<thead>
<tr>
<th></th>
<th>SAGD</th>
<th>SAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOR</td>
<td>2</td>
<td>1.4</td>
</tr>
<tr>
<td>Recovery</td>
<td>65%</td>
<td>(as high as) 90%</td>
</tr>
<tr>
<td>Lower Capital Intensity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower Emissions</td>
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<td>Less Water Usage</td>
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<tr>
<td>Possible In Situ Upgrading</td>
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Encana’s Senlac SAP Pilot 2001-2002

Senlac Thermal Facility – Phase C

To assess

- Rate enhancement
- Solvent retention
- In situ upgrading
Senlac SAP Test

Senlac Pilot, 2001-2002
- Butane used as solvent
- Oil rate increase of over 50%
- Test cut short due to reservoir containment issue
Senlac SAP Test

Senlac Pilot, 2001-2002
- Butane used as solvent
- Oil rate increase of over 50%
- Test cut short due to reservoir containment issue
- approx. upgrading: 1^0 API
  - (over base level 12.7^0 API)
Senlac SAP Test

Senlac Pilot, 2001-2002
- Butane used as solvent
- Oil rate increase of over 50%
- Test cut short due to reservoir containment issue
- approx. upgrading: 1° API
  - (over base level 12.7° API)
- Over 70% solvent recovery
Encana’s Christina Lake SAP Test

Christina Lake SAP Pilot, 2004-2007
- Prove (Athabasca context)
  - rate acceleration
  - solvent retention
  - In situ upgrading
- Pilot started July 2004
SAGD and beyond

In situ Processes and Energy Efficiency

<table>
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<tr>
<th>Energy/bbl</th>
<th>SAGD</th>
<th>SAP</th>
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<td>Commercial</td>
<td>Under development</td>
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</table>
Solvent without steam - VAPEX

- Prospects
  - Minimal energy requirement
  - No water recycle issue
  - Some downhole upgrading

- Awaiting field scale demo

- Several efforts to field test in oilsands:
  - Encana’s Foster Creek VAPEX Pilot
  - Consortium DOVAP
  - SunCor’s ETS
SAGD and beyond

In situ Processes and Energy Efficiency

Energy/bbl

<table>
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<th>SAGD</th>
<th>SAP</th>
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SAGD

It costs to heat

Reduction in Cost of Heat

Use cheaper fuel

- Bitumen/Residue to substitute Gas
  - Nexen/OPTI
- Other talked-about alternatives
  - Coke/Coal/Nuclear

Reduce heat requirement

- Process Improvement
  (Also reduces water requirement)
  - Low Pressure Operation
  - Use of Solvents
    - SAP (SAGD + solvent)
Cheaper Fuel

- Air
- Product oil
- Secondary Upgrading
- Fuel
- Fuel + H₂
- Primary Upgrading
- Residue Gasification
- Thermal Recovery
- Sub-surface

Secondary Upgrading
- Fuel + H₂

Primary Upgrading
- Residue Gasification
- Fuel + H₂

Steam Generation
- Fuel
- Product oil

Thermal Recovery
- Secondary Upgrading
- Primary Upgrading
- Residue Gasification
Cheaper Fuel

Air → Product oil → Primary Upgrading → Residue Combustion → Heat → Steam Generation → Thermal Recovery
Everything in the Reservoir?
Imagine that!
The prized pursuit ..

In Situ Combustion

In theory this is great!
- minimal fuel requirement
- high recoveries
- no reservoir loss of pricier substance
The prized pursuit ..

In Situ Combustion

In theory this is great!
- minimal fuel requirement
- high recoveries
- no reservoir loss of pricier substance

- Petrobank’s Whitesands 3-wells Pilot
- Location: South of Ft. McMurray
- Time-frame: 2005-2008
- Proponents expect a $6/bbl cost reduction

Source: based on Petrobank website information, Fort McMurray Today
To recap ..

- World demand for energy in the near future will grow.
- Although the conventional oil supply is predicted to decrease, non-conventional economic oil sources are ready to step up and fill the gap.
- SAGD is emerging to be the technology of choice for the expanding exploitation of Oilsands of Alberta.
- Energy efficiency and economics of SAGD will significantly improve through steps such as SAP.
- Dramatic improvement in recovery process are expected if VAPEX or In Situ Combustion prove successful.
- We live in exciting times to witness and be a part of a revolution in the Energy Technology!