30th Annual CNS Conference

Energy for Oil Sands Production

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What is happening?

- In the long term the energy demand will increase due to the world population increase and expected economic growth.
- Supply of easy oil can not keep up with the increase in demand.
- Oil will stay as the main source of the transportation fuel in the foreseeable future.
- Globally production of heavy crude is increasing.
- More energy production means more CO2 emitted at a time when climate change looms as a critical global issue.
- Obama’s energy policy will have a profound impact on oil sands development.
World oil production by OPEC/non-OPEC

Production rises to 104 mb/d in 2030, with Middle East OPEC taking the lion’s share of oil market growth as conventional non-OPEC production declines

Source: IEA
World oil production by source in the Reference Scenario

64 mb/d of gross capacity needs to be installed between now and 2030 to meet demand growth & offset decline.
97% of the projected increase in emissions between now & 2030 comes from non-OECD countries – three-quarters from China, India & the Middle East alone.
Oil Sands 101
The Bitumen Recovery Challenge

![Graph showing viscosity vs. temperature for various samples: Water, Olive Oil, Pancake Syrup, Honey, Ketchup, Cold Lake Bitumen, and Athabasca Bitumen.]

- Temperature (°C)
- Viscosity (cP)

- Cold Lake
- Athabasca

![Graph showing viscosity curves for Cold Lake and Athabasca bitumen.]

- Temperature (°C)
- Viscosity (cP)
The Resources
The Largest Oil Resources in The World

Figure 1. Worldwide Distribution of Conventional Crude Oil and Heavy Hydrocarbons
Proven World Crude Oil Reserves

Sources: Oil and Gas Journal – Dec 2002, AEUB
<table>
<thead>
<tr>
<th>Region</th>
<th>GDP Increase ($ Billions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alberta</td>
<td>1,167</td>
</tr>
<tr>
<td>Other Provinces</td>
<td>310</td>
</tr>
<tr>
<td>Outside Canada</td>
<td>268</td>
</tr>
</tbody>
</table>

*Canadian Energy Research Institute, *Economic Impact of Alberta’s Oil resources*, August 2006
Energy Intensities

1995 Industry Average PEI GJ/m3OE

- CHO
- CHO (adj vent and trucking)
- Light Oil
- SAGD Thermal
- CSS Thermal
- Expanded Resource

Energy Recovery Ratio
1 Unit In = 4 Units Out

Diminishing Net Energy Returns

Source CAPP
GHG Intensities

1995 Clearstone PCI kg/bbl

- CHO
- CHO (Adj for truck CO2)
- Light Oil
- Bitumen (Mining)
- Bitumen (in-situ)
- Upgrading
- Expanded Resource

Add CO2 from Upgrading

CO2
CH4
PTAC’s Technology Options to Reduce GHG Emissions from Oil Sands

- CO2 sequestration
- Eco efficiency Program
- Emerging exploitation technologies (FGSS, etc.)
- Alternative solutions to replace natural gas consumption
Use of Natural Gas:
Is it a poor use of a clean fuel?
Do we have enough gas?
Alternative Solutions to Replace Natural Gas

- Gasification of coal, coke or asphaltenes, etc. combined with CO2 sequestration
- Burning bitumen combined with CO2 sequestration
- Nuclear
- Other options
Gas Consumption Forecast

Source: Canadian Association of Petroleum Producers
Oil Sands Production Forecasts
Forecast Risked Growth

Risked Production Growth

Year

Production (MMbbls/d)

Base
Expansion
Active
Announced

2006 2010 2015 2020
Comparative Production Forecasts

- **Production (MMbbls/day)**
- **Year**

- **CAPP**
- **CERI**
- **NEB**
Natural Gas Consumption

Natural Gas Consumption by Technology

- **Upgrading Process**
- **Extraction Process**

<table>
<thead>
<tr>
<th>Process</th>
<th>Mcf/barrel</th>
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<tbody>
<tr>
<td>Mining</td>
<td>0.5</td>
</tr>
<tr>
<td>In Situ</td>
<td>1.2</td>
</tr>
<tr>
<td>OPTI Ormat Process</td>
<td>0.3</td>
</tr>
<tr>
<td>THAI</td>
<td>0.6</td>
</tr>
</tbody>
</table>
Gas Supply and Demand

Projected Canadian Natural Gas Supply/Demand Balance

mmcf/day

- LNG
- MACKENZIE
- ATLANTIC
- WCSB (CON. & UNCON.)
- OIL SANDS DEMAND
- DOMESTIC DEMAND

GHG Emissions

GHG Emissions, 2006 - 2020 (t/d)

In-Situ

Mining
Application of Nuclear Technology – Opportunities

- Low operating cost
- Reliable
- Emission-free energy
- Flexibility in generating steam, hydrogen, heat, and electricity
- Reduction in consumption of natural gas
- Energy cost certainty
- Reduces premium fuel availability concerns
- High tech jobs
Application of Nuclear Technology – Challenges/Considerations

- High capital cost
- Technical feasibility and economic viability
- Distance to transport steam economically
- Size dictates next generation reactors
- Construction challenges: remote site with difficult access
- Harsh weather conditions
- Labor/skills shortages
- Lack of experience with nuclear technology or nuclear power generation
- Lack of regulatory frame work
- Safety
- Security
- Commercial application is likely post 2025
Application of Nuclear Technologies

- Phase 1: Evaluate nuclear technologies for oil sands application
- Phase 2: Study of application of high temperature gas reactors to in-situ operations
- Phase 3: Detailed Engineering study
- Phase 4: Implementation of field pilot tests
Phase one: Evaluated Options

- 120,000 BPD In-situ (SAGD), constructed in four (4) 30k BPD stages;
- 100,000 BPD Mining; and
- 100,000 BPD Integrated Mine and Upgrader.
Mining and In-Situ

- Bitumen production
- Project life
- Steam oil ratio
- Pressure at well head
- Steam quality
- Electricity requirement
- Mining and in-situ/Integrated
Study Results

- NPPs with water cooled reactors have thermal capacities greatly exceeding the energy requirements of the evaluated options.
- Water cooled reactor are not hot enough to generate steam for SAGD
- High Temperature Gas Reactors (HTGRs) could meet the technical requirements for the three (3) scenarios considered, but are not currently commercialized.
- Among the considered technologies are the Pebble Bed Modular Reactor (PBMR), Toshiba 4S, and the General Atomics High Temperature Gas Reactor (GA-HTGR).
The introduction of nuclear energy into the Oil Sands region will be a lengthy and expensive process. The timing is likely post 2025. The Project duration, including site selection, environmental assessment, licensing and construction could span over 15 years. A practical way of utilizing the existing commercial NPP designs for use in the Oil Sands region would be to adopt a ‘utility’ approach for the delivery of energy (in the form of steam and electricity) to multiple Oil Sands facilities, and for providing electricity to the Alberta power grid.
Conclusions

- Development of Canada's Oil Sands resources are essential to meet the global energy demand and stimulate Canada’s economic prosperity.

- Application of existing and emerging technologies can ensure sustainable development of Canada’s world class Oil Sands resources.
Thank You