Imperial Oil Centre for Oil Sands Innovation at the University of Alberta

Presentation to GCEP Workshop
November 11-12, 2005
Monterey, CA
World Oil Reserves

- Saudi Arabia: 262 billion barrels
- Rest of OPEC: 538 billion barrels
- Rest of World: 257 billion barrels
- Conventional: 13 billion barrels
- Oil Sands (Low): 175 billion barrels
- Oil Sands (High): 300 billion barrels

Oil reserves, billions of barrels
Oil sand deposits in Alberta and operating commercial plants

Province of Alberta
(Courtesy of Syncrude Canada Ltd.)
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Oil Sands

- Thick beds from near surface to 1000 m depth
- Sand + Water + Oil + Clay + Salt
- Good ore >8% bitumen by weight

Suncor Steepbank Mine
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Extraction of Bitumen
Properties of Bitumen

- Density $\geq 1000$ kg/m$^3$
- Viscosity $> 10^6$ mPa.s at 15 °C
- Sulfur = 4.5%
- Nitrogen, oxygen, vanadium and nickel
Upgrading of Bitumen

Syncrude Upgrader

Suncor Millennium

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Tailings from Oil Sands
In Situ Production with Steam
SAGD recovery
Natural Gas Supply

Assume:
1. 4 million bbl/d upgraded products
2. 1 million bbl/d sold as dil bit
3. 50/50 between mining and in situ

From ACR Oilsands Technology Roadmap 2004
## Efficiency of Production + Upgrading Schemes – CO₂ Release

<table>
<thead>
<tr>
<th>Case</th>
<th>Production kg CO₂/bbl</th>
<th>Upgrading kg CO₂/bbl</th>
<th>Total kg CO₂/bbl</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mining + Upgrading</strong></td>
<td>45</td>
<td>37</td>
<td>82</td>
</tr>
<tr>
<td><strong>SAGD + Gasification + Upgrading</strong></td>
<td>95</td>
<td>37</td>
<td>132</td>
</tr>
</tbody>
</table>

Source: Bitumen and Very Heavy Crude Upgrading Technology, Len Flint, 2004. -Upgrading to 34 °API sweet blend
Mission for COSI

To identify and fund key areas of oil sands research and development that will lead to continued economic growth in Canada and to meaningful environmental progress which also provides business benefits for Imperial Oil
Principles for COSI

- Focused on the development of more energy efficient oil sands processes with improved environmental performance
  - breakthrough vs incremental improvement of existing processes
  - in situ recovery process technologies outside scope of the initiative
- Mission oriented fundamental and applied research; focused in areas of strategic interest to Imperial
- IOL funded with matching funding from the federal and provincial government
  - $2 million/year from IOL, plus ca. $500K/year of in-kind support
- Operated and staffed by the U of A
  - collaboration with other Universities on projects
- Collaborative endeavor with consensus decisions
- Long term - initial 5 year terms; renewable
Structure and Governance

- Executive Management Committee
- Scientific Advisory Committee
- Centre Director
- Centre Manager
- RAs and Technical Staff
COSI - Intellectual Property

• U of A owns all IP arising from the research at the COSI
  – U of A immediately assigns exclusive use rights to Imperial and affiliates; world-wide, royalty-free, fee-free license to use all IP

• U of A ownership of IP enables partnerships with AERI on projects
COSI - Roadmap & Milestones

SAC accepts proposals for evaluation and selection

IOL COSI at U of A announced Oct 25

Active research programs in key areas of interest

Major review of COSI progress, direction, etc.

2 or 3 research process concepts ready for demonstration pilot

Time

04 05 06 07 08 09
COSI Research Gate Process

U of A Researcher
IORL

Idea/Lead Generation

Gate 0
Concept

Concept Development

Gate 1
Research Project

Research Project

Gate 2
Demo Pilot

Field or Demo Pilot

Gate 3
Commercial Ready

$, Time, Technical Certainty, Business Certainty, Business Relevance, Economics, Operations Integrity, etc.

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Esso

Imperial Oil
COSI Project Development

- Focus on breakthrough vs incremental improvement of existing processes
- Cohesive series of research projects, aligned with objectives
- COSI is not a collection of unrelated research projects
- Several years before projects reach Gate 2 (Demo Pilot Stage)
Oil Sands Value Chain Today

- Trucks and Shovels
- Aqueous extraction
- Naphtha froth treating
- Paraffinic froth treating
- Coking with secondary hydrotreating
- Hydroconversion (LC Fining)
- Solvent deasphalting
- Diluent addition

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Technology “S” Curve and Breakthrough

Existing Technology Curve

Sustaining Mastery
Building of foundations; improving, augmenting, applying

Diminishing Returns

New Technology Curve

Pioneering Science and Engineering
Prospecting for new possibilities; exploring, inventing, evaluating

Measure of Advancement

Measure of Applied Effort

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Example Research Opportunities

- Production technology for smaller mines and for deeper deposits
- Non-aqueous extraction and water treatment to eliminate tailings and water consumption
- Improve molecular management of bitumen during processing
- Integration of processing steps
Project Development – 2004/05

• Workshops on oil sands technology (2004/11)
• Brainstorming sessions on new production, extraction and upgrading (2005/01)
• Solicited Letters of Intent (2005/02)
• Invited full proposals and issued RFP (2005/04)
COSI Projects 2005

- **Call for letters of intent – February 2005**
  - 37 letters of intent from U of A researchers
  - Met with researchers to discuss 18 LOI
  - Requested full proposals on 5 projects (some projects were combined)

- **Project selection – May/June 2005**
  - 7 proposals received and evaluated using Gate process
  - Internal peer review at U of A and IOL, focus on improvement and check on novelty
  - 2 projects recommended for funding
  - Ongoing discussion on several additional projects

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Observations on 2005 Round

• Good participation by researchers already active in oilsands
• Little success bringing new researchers to the field
• Partial success in combining related ideas into integrated projects
  – Project leadership will need stewarding
Exploratory Synthesis and Modeling of New Bitumen Catalysts and Processes

- Kovalenko (NINT), Kuznicki and McCaffrey (Chemical and Materials Engineering)
- New approach to catalysis to enable lower-temperature conversion
- Integrate conversion and extraction
- Patent disclosure in preparation

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Selective Separation of Vanadium and Nickel Compounds from Bitumen

- Gray and Kuznicki (Chemical and Materials Engineering), Fenniri (NINT)
- Selective removal of V- and Ni-bearing molecules from bitumen would reduce yield by only 1%
- New separation methods intended to achieve much greater selectivity than asphaltene precipitation and extraction
Project Development 2005/06

• Workshops on fundamentals of science and engineering for oilsands
  – Stronger participation by researchers from Chemistry, Materials
  – More productive of research ideas and questions for follow-up evaluation

• Letters of Intent due Dec 1/05

• Meetings with researchers to follow up
Observations

- Shepherding of projects is essential
  - “High touch” not “high tech”
- Analysis is much easier than innovation
Future Challenges

• Managing expectations at Imperial Oil and at University
  – Level of commitment versus success rates
  – Recruitment of new faculty who commit to COSI, but whose ideas might be rejected
  – Commitment of current and new faculty to COSI versus other activities (U of A receives oil sands funding from 7-10 other companies)
  – Partnering with other universities