Alberta Oil Sands
Future Positioning

Presentation from: Duke du Plessis and Eddy Isaacs
Alberta Innovates, Energy & Environment Solutions (AIEES)

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Gerald W. Bruce, CCQTA

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Who is AIEES

- Alberta Innovates – Energy and Environment Solutions
  - Technology implementation arm of the Government of Alberta Ministries of Energy and Environment
  - Last known as AERI, 2000 to 2009
    - Alberta Energy Research Institute
      - Alberta Oil Sands Technology and Research Authority
      - SAGD development

- Develop innovative, integrated ways to convert Alberta’s natural resources into market-ready, ecologically responsible energy
  - Research, innovation and technology development
  - Funding
Overview

• Alberta Government Programs and Initiatives
  → Advancing technology for:
    • Upgrading bitumen, GHG emission reduction, alternative energy, carbon capture

• Sustainability focus
  → Life Cycle Analysis Project
    • Well to wheels
## Government Programs and Initiatives

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<tr>
<th>Program/Initiative</th>
<th>Description</th>
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<tr>
<td>Carbon Capture and Storage (CCS) Fund ($2 billion)</td>
<td>Large-scale demonstration plants capable of storing 5 million of CO₂ annually by 2015. Three projects qualified for potential funding – EPCOR Clean Coal, Shell and Enhance Energy.</td>
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<td>Climate Change &amp; Emissions Management Fund (currently at ~$120 million)</td>
<td>Technology fund to offset emissions from large facilities and promote GHG reductions – ‘greening’ of energy system, efficiency, CCS. Expression of interest process underway.</td>
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<td>Innovative Energy Technology Program ($200 million)</td>
<td>Develop new energy supplies from existing oil and natural gas reserves, as well as from in situ bitumen and heavy oil deposits. Over 20 pilot projects underway.</td>
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<td>EcoTrust Fund ($156 million).</td>
<td>Reduce GHG and air emissions of concern. Thirteen projects approved and agreements being negotiated.</td>
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<td>AERI-Industry Programs. ($44 million last year) with similar or greater investment by industry</td>
<td>Technology development and demonstration in 6 strategic areas.</td>
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<td>Bitumen royalty-in-kind.</td>
<td>The government royalty share of bitumen made available to upgrade to higher valued products in the province. Selection of projects underway.</td>
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Research and Technology Development Activities
(Partnership with industry & other government programs)

**Production**

- **Mined Oil Sands:** Reduce water for extraction
  - Dense phase processes
  - Solvent-Water processes

- **In situ extraction:** Reduce Water, Natural Gas and Diluent Requirements
  - Enhancements to SAGD
  - Thermal-solvent processes
  - Heated solvent
  - Combustion
  - Electrical heating

- **Upgrade Bitumen to higher value products**
  - Advanced Upgrading and Gasification Technologies:

- **Unconventional natural gas**
  - Develop economic recovery technologies for Coal Bed Methane, Tight Gas and Shale Gas

- **Coal**
  - Clean Power Generation: IGCC with CO₂ capture
  - Underground Coal Gasification

**Environment**

- **Water recovery from tailings ponds:**
  - Reduce use of tailing ponds
    - Consolidated tailings process: Currently practiced
    - Improved thickening - better flocculants,
    - Dry tailings – filter belts,
    - Evaporative/Chemical Drying
    - Paste technology
    - CO₂ for Consolidated Tailings processes

- **Carbon Capture and Storage (CCS)**
  - Pre- post combustion capture technologies
  - Integrated Coal Gasification Combined Cycle (IGCC) with CO₂ capture
  - CO₂ Enhanced Oil Recovery
  - End-to-end Demonstration Plants ($2 B government investment)
Achieving Clean Energy Goals – Oil Sands Technology Framework

- New wave - efficient oil sands production technologies
- Next generation upgrading technologies (integration with gasification and CCS)
- Carbon capture & storage → Includes CO₂ EOR
- Gasification of pet coke, asphaltenes, coal, biomass
- Combustion of liquid/solid fuels
- Unconventional natural gas
- Nuclear outlook

- Research & technology adaptation costs
- Capacity – human, infrastructure
- Large scale deployment time horizon
- Comparative Life Cycle Analysis
Hydrocarbon Upgrading Demonstration Program and Related Studies

- 2005 government – industry workshops
  → identified barriers to upgrading bitumen to high value products in Alberta

- Hydrocarbon Upgrading Development Program (HUDP) focused on ‘breakthrough’ technologies
  → to reduce the cost and environmental footprint of upgrading bitumen to
    - high value products
      - Synthetic Crude Oil (SCO) and beyond

- Screening study with industry group
  → Considered 100 process/technologies.
    - Selected technologies
• Stage-gated industry-government engineering and piloting studies of selected technologies. → 2007 to date
• Broadened scope → to include partial Upgrading technologies.
• Life Cycle Analysis (LCA) GHG emission studies
• Energy efficiency studies
• GHG mitigation roadmap
Primary Upgrading and Residue Gasification Schemes Evaluated

- Primary Upgrading
  - Coking
  - EB HC
  - SHC

- VDU
- Hydrotreating
- Hydrocracking

- SMR
- Make-up NG

- In-plant use or export

- Gasifiers - existing & new

- Refined Products Petrochemicals

- Electricity Fuel Gas

- 66,00 bpd Diluent
- 266,00 bpd Dil-Bit
- 200,000 bpd Bitumen

- Coke or Pitch
Status of Hydrocarbon Upgrading Development Program (HUDP) Projects

- **ETX System Cross-flow Coking:**
  - Lower coke yield
  - Higher and better quality products
  - Completed 1 b/d pilot tests (NCUT = National Centre for Upgrading Technology)
  - Want to move build demonstration plant

- **UOP Slurry Phase Hydrocracking:**
  - Advanced secondary upgrading process (slurry phase hydrocracking)
  - Higher conversion: 90% +
  - Based on 5000 bpd demonstration tests of the process at the Petro-Canada Montreal refinery in 1980’s
  - Currently being piloted at UOP, NCUT and StatoilHydro
  - Developing advanced catalysts to further improve performance.
Status of HUDP Projects—continued

- **Nova Chemicals:**
  - Converts bitumen-derived heavy gas oils into paraffinic petrochemical feedstocks.
  - Catalysts work in China and Germany
  - Performance tests at NTRC, Calgary
  - Piloting underway at NCUT, Devon
  - On-going R&D aims to broaden the range of feedstocks

- **Great Point Energy:**
  - Single stage catalytic gasification of coke to Synthetic Natural Gas (SNG)
    - Fluidized bed reactor
  - Completed pilot trials with coke and coal at GTI, Chicago
  - Seeking partners for demonstration project
Status of HUDP Projects - continued

- **Pratt & Whitney Rocketdyne:**
  - Advanced compact dry feed gasifier
  - Potentially lower capital & operating costs
  - 18 t/d pilot plant being commissioned at GTI
  - High pressure solids feed pump being developed at EERC
    - EERC = Energy and Environment Research Centre, Grand Forks, ND

- **Advanced Solvent Deasphalting:**
  - Novel solvent de-asphalting concept
  - Conceived during the initial phase of HUDP
  - Potentially lower capital & operating costs
  - Being evaluated in bench scale test with bitumen-derived feedstock
Technology Summary

- Alberta will play an increasing role in meeting world energy demand growth:
  - size of resource, secure supply, strategic location in NA, future access to Asian markets
- Existing government strategies to improve competitiveness and environmental footprint of oil sands operations
- Oil sands products meet current refinery quality specifications
  - (alone or as blended feeds) and can be processed further to meet more stringent market requirements
- Opportunities for international participation business and technology developments
Sustainability and Environmental Focus

LIFE CYCLE ANALYSIS
PROJECT
EES Life Cycle Analysis Project

- Life Cycle Analysis (LCA) was started to understand the impact of oil resources on greenhouse gas (GHG) emissions

- Limitations of prior LCA
  - Simplified, generic model representations
    » Crude production and refinery configurations not well differentiated

- Decision to conduct two independent studies (TIAAX LLC and Jacobs Consultancy) to establish the impact of crudes processed in U.S. refineries
  - Well-to-wheel LCA direct emissions only
**GHG Emissions – Production Factors**

- **Variation in GHG Emissions:**
  - Depth
  - Pressure
  - Water-oil ratio
  - Gas-oil ratio
  - Venting
  - Flaring
  - Offshore production
  - Transportation
  - Steam-oil-ratio

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**Modelling Crude Production**
Comparison of Oil Production GHG Emissions – Jacobs Study
Sources of Crude Oil in US Refineries - 2007

- US - Other: 17%
- US Gulf Coast: 17%
- California: 3%
- Iraq: 3%
- Nigeria: 7%
- Venezuela: 7%
- Canada: 11%
- Saudi Arabia: 9%
- Mexico: 9%
- Rest of the world: 13%
- Angola: 4%
GHG Emissions
– Upgrading and Refining Factors

- Crude quality and product requirements:
  → Processing complexity
  → Hydrogen addition
  → Energy consumption
  → Product yield and consistency
  → Handling co-products such as coke

- Refinery configuration and technology:
  → Level of conversion
  → Product slate (gasoline, diesel etc.)
Comparison of Refining (Upgrading) GHG Emissions for Gasoline – Jacobs Study
Comparison of Total GHG Emissions of US Domestic and Imported Crudes – Jacobs Study

Band: Average Oil Sands* (107.6) – Average all Crudes (103.7) in US Refineries

*Oil Sands: 55% mining/SCO, 40% SAGD-Dilbit, 5% SAGD-SCO
LCA Comparison TIAx vs. Jacobs – Total GHG Emissions Reformulated Gasoline

- Saudi
- Mexico
- Iraq
- Venezuela
- SAGD-Dilbit
- Mining-SCO
- California Heavy

Graph showing Total GHG Emissions gCO\textsubscript{2}e/MJ gasoline for each location.

SAGD-Dilbit
(SOR = 3; adjusted)
No electricity credits
Emissions from oil sands are comparable to conventional crudes entering US refineries.

- Methodology for cogen credits is uncertain.
Impact of Technology Advances - SAGD Bitumen (Estimate)

LCA Studies - SAGD Bitumen

Best-in-class SAGD

Steam-solvent

Next wave technology

Eq. steam-oil ratio

Total GHG, g CO$_2$e/MJ gasoline
Summary Drawn from Life Cycle Analysis Reports

- A wide range of GHG emissions for crude oils in North American refineries
- Imported and U.S. domestic heavy oil crudes have similar emissions to the oil sands pathways
- With some overlap, oil sands pathways generally have 10% higher emissions than conventional crudes
- GHG emissions from oil sands crudes are comparable to conventional crudes when potential cogeneration credits are considered
- Technological advances will further decrease GHG emissions for oil sands crudes
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