Eddy Isaacs
Alberta Energy Research Institute (AERI)

Eddy Isaacs is the Executive Director of the Alberta Energy Research Institute (AERI) with responsibility for Alberta’s strategic directions and investments in energy innovation areas that include conventional and unconventional oil and gas, coal, petrochemicals, renewable energy and carbon and water management.

He has been instrumental in promoting innovation in energy and environment across Canada and is the co-Chair of the Energy Technology Working Group of the Canadian Council of Energy Ministers.

Eddy holds a Ph.D. from the University of Alberta and a B.Sc. from McGill University. He has over 70 publications and 6 patents in the energy field.

Previously, Eddy served for more than 20 years with the Alberta Research Council (ARC) where he was responsible for ARC’s programs in heavy oil and oil sands. He also served as an adjunct professor in the Department of Chemical and Material Engineering, University of Alberta.

Eddy serves on the Boards of the Petroleum Technology Alliance of Canada (PTAC), Canadian Oil Sands Network for Research and Development (CONRAD) and NRC’s Fuel Cells Innovation Institute and is a Fellow of the Canadian Academy of Engineering.

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Shaping the Future – Innovation in Energy and Environment

Eddy Isaacs, Ph.D., Executive Director
Alberta Energy Research Institute (AERI)

Alberta’s prosperity is closely linked to the sustainable long-term growth of its abundant energy resources including oil, natural gas, oil sands, coal and renewables. Advanced technology is an essential factor enabling the energy sector to create: high skilled, high-income workers; the bulk of Alberta’s revenue and exports and the diversification to valuable products and services. The potential to add such value in the future requires an integrated and balanced approach that minimizes environmental impacts and utilizes Alberta’s energy resources to optimize economic benefits.

This presentation focuses on the emerging technologies and innovations that can be applied to produce and add value to Alberta’s energy resources and products while decreasing impact on greenhouse gas emissions. The strategy is to focus on the innovation needed together with progressive government policies and actions to stimulate next generation technology platforms such as upgrading, gasification, carbon capture and storage and advanced recovery methods thereby ensuring a transition to a lower carbon energy economy.
Shaping the Future – Innovation in Energy and Environment

NCUT 5th Upgrading & Refining Conference: September 14 - 16, 2009

Eddy Isaacs, Executive Director
Alberta Energy Research Institute
(www.aeri.ab.ca)
Government-Industry Collaboration: An Oil Sand Success Story

- AOSTRA was formed in 1974 as the Province’s response to the 1973 oil crisis:
  - Develop technologies that would allow the vast oil sands resources to be exploited at economic rates
  - Fill the gap of declining conventional oil

- AOSTRA invested $80 MM in Underground Test Facility (UTF) – led to SAGD in situ process
  - Industry consortia joined later - shared the risks
  - Over 30 Pilots ~$1 Billion
  - Spawning several less energy intensive variations
  - Trained industry technical experts and today’s management leaders
Benefits from SAGD to Gov’t and Industry

Government Revenue = Royalties + Taxes to 2020

Cost = Government Investment in R&D

CERI Study (1999)

Revenue to cost

SAGD Producing Companies

1989
Numerous Experimental Projects

2009
Encana JACOS PetroCanada
Suncor Connacher Devon
Nexen ConocoPhillips Total

Not an all inclusive list
New 21st Century Crisis?

- Changing global energy landscape
  - Unprecedented growth in energy demand
  - Climate change
  - Energy security
  - Huge investment in infrastructure needed

- Rapid development of the Alberta energy industry
  - Concerns over environmental impacts
  - Increasing GHG emissions
  - Increasing fresh water use
  - Natural gas use
  - Maximizing value of energy products
Alberta Energy Research Institute (AERI) (transitioned from AOSTRA in 2000)

- **Mission:**
  - Enhance the development of clean energy resources through research, technology and innovation.

- **Mandate:**
  - Position Alberta for the future in energy
  - Add value to Alberta’s energy resources

- **Strategy:**
  - Invest in technology development projects with industry
  - Partnerships & International collaboration
  - Focus on Technology Platforms such as Advanced Recovery, Upgrading, Gasification and Carbon Capture and Storage (CCS)
# Government Programs and Initiatives

<table>
<thead>
<tr>
<th>Program/Initiative</th>
<th>Description</th>
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<tbody>
<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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<tr>
<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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<tr>
<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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Climate Change & Emissions Management Fund

- Climate Change & Emissions Management Corporation Established
  - Not-for-profit, independent
  - Objective: Fund initiatives that reduce GHG emissions

- Initial Funding Areas
  - Conserving and using energy efficiently ~20%
  - Implementing carbon capture & storage ~ 30%
  - ‘Greening’ energy production ~50%

- Expression-of-Interest due September 30th, 2009

www.CCEMC.CA
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 – AERI’s 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
Major R&D Programs Designed to Support Current and Next Generation Technologies

1. Alberta Ingenuity Center for In Situ Energy
   Focus on in situ upgrading technology

2. AERI/ARC Core Industry Research (AACI) Program
   Energy efficient in situ recovery of heavy oil and oil sands

3. Alberta Ingenuity Center for Oil Sands Innovation
   Focus on non- & less- aqueous oil sands extraction and novel upgrading technologies

4. National Center for Upgrading Technology (NCUT)
   Focus on pilot testing of novel upgrading technologies
NCUT Piloting Support of AERI’s Hydrocarbon Upgrading Demonstration Program

Nova NHC and ARORINCLE Technologies produce Olefins and Gasoline from bitumen-derived gas oils

ETX Crossflow Coking – superior liquid yields

UOP Slurry Phase Hydrocracking (CANMET technology) high conversion yields for bitumen and heavy oils
AERI’s 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 (TIAX LLC and Jacobs Consultancy) to establish the impact of crudes processed in U.S. refineries
  - Well-to-wheel LCA direct emissions only
LCA Comparison TIAx vs. Jacobs - Total GHG Emissions Reformulated Gasoline

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<thead>
<tr>
<th>Location</th>
<th>TIAx</th>
<th>Jacobs</th>
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<tr>
<td>Saudi</td>
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<td>Mexico</td>
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<td>Iraq</td>
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<td>Venezuela</td>
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<tr>
<td>SAGD - Dilbit</td>
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<td>Mining - SCO</td>
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<td>California Heavy</td>
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SAGD- Dilbit
(SOR = 3; adjusted)
No electricity credits

Total GHG Emissions gCO₂e/MJ gasoline
Wide range of emissions for conventional and heavy crude oils in US refineries

Determined by geological, reservoir, production and transportation factors

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
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 CO₂e/MJ gasoline
Oil Sand - Technology Options for GHG Reductions

- Increased efficiency of operations
- Reduction in energy intensity of existing processes
- Switching to new generation processes
- Fuel switching
- Carbon capture and storage
Economics of CO$_2$ Capture
(Fort McMurray Area)

CO$_2$ capture cost, $$/tonne

CO$_2$ Concentration, %

CO$_2$ supply curve to 2020
SMR + gasification (medium case)

AERI Sponsored ARC Study, 2009
CO₂ Storage Potential in WCSB

- Potential for large storage capacity based on high level screening studies
Complementary Initiatives
- pipeline placement vs. open aquifers vs. reef vs. basal sand

1. **ASAP Phase 1**: Identify best three deep saline aquifer sites; design pilot

2. **Wabamun Phase 1**: Practical application of the geo-storage risk management modelling work

3. **Redwater Phase 1**: Specific site – reservoir delineation and pilot design

4. **Quest Phase 1**: Drill wells and field test

**Saline aquifers provide excellent storage potential – but need better reservoir delineation and injectivity analysis**
$2 Billion CCS Fund
(Kick Start CCS: ‘learning-by-doing’ projects)

- **Enhance / Northwest** - Alberta Carbon Trunk Line to EOR sites in central Alberta. It captures CO₂ from the Agrium fertilizer plant and the Northwest upgrader (gasification).

- **EPCOR/Enbridge** - integrated gasification combined-cycle carbon capture power generation facility, west of Edmonton. Saline formation injection sites

- **Shell Quest** - A fully integrated carbon capture and storage project at the Scotford Upgrader and nearby saline aquifer injection sites.
Promote innovation to ensure sustainable development of Alberta’s vast energy resources (oil sands, carbonates, unconventional gas, coal, pet coke, renewables)

- Sustained investment in targeted research commensurate with benefits
- Risk sharing mechanisms with industry for higher risk and costly demonstration & commercialization of technology
- International collaboration to advance critical technology platforms – gasification, CCS and upgrading

Initiatives focused on CO₂ emissions, water management, enhanced ecology, advanced recovery and upgrading, gasification

Alberta as an international leader in energy and environmental technologies