In Situ Oil Sands Plays & Technologies

Caralyn P. Bennett, P. Eng.
Vice President – Oil Sands
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Discussion Snapshot

- Oil Sands Significance
- Development to Date
- Emerging Play Types
- Technology Evolution
- Project Uncertainty
- Reserves Criteria
Do the oil sands matter?
Energy Sector

$100 billion annual energy industry revenue

$67 billion estimated industry investment for 2013

$18 billion of average annual energy sector payments to government

20% of value of TSE

550,000 employed directly & indirectly

Source: CAPP
Motivation for Sustainable Development

### Oil Sands

- **$91 billion of Canada’s GDP in 2012**
- **3% of Canada’s 2012 jobs**
- **Forecast 5% by 2025**
- **$1.3 billion annual revenue to Aboriginal business**
- **$25 billion estimated oil sands investment for 2014**
- **Forecast $61 billion 2025**
- **55% of Alberta’s resource revenue from oil sands in YE2014**
- **Forecast 61% YE2015 70% YE2017**
- **1.8 million bopd 2012 production**
- **Forecasts 3.8 million bopd in 2025 by IHS**
- **4.5 million bopd in 2025 by CAPP**

Source: IHS, CAPP, Alberta Government
The Resource Target

Regions in Perspective

Bitumen Initially in Place
1844 Billion bbl

- Athabasca: 83%
- Cold Lake: 10%
- Peace River: 7%

Source: AER ST 98 2013
Climbing the Development Ladder

2017
- proposed first commercial solvent SAGD (Cenovus Narrows Lake)
- proposed first commercial vertical steam drive - Shell Carmen Creek
2016
- proposed first commercial horizontal CSS carbonates - Larchina Saleski
- proposed first commercial SAGD Grand Rapids - Larchina Germain
2014
- NSOLV test at Suncor Dover
- ESE/I/HE pilot at Suncor Dover
2013
- pad blow down initiated
2012-2013
- TAGD proof of concept test at Athabasca Dover West carbonates
- emSAGD pilot combining infills and NCG injection at MEG Christina Lake
2011
- ESPs (250 degree C)
2010
- pad wind down initiated
- enhanced start-up strategies
- gas cap repressurization
- modern carbonate pilot initiated at Larchina Saleski
2009
- multi-module construction phasing
- infills in SAGD at Cenovus Foster Creek
2008
- first mine reclamation certificate issued
2007
- first commercial late life solvent addition to steam at Imperial Cold Lake (LASER)
2006
- first Cold Lake commercial SAGD - Husky Tucker
2005
- Grand Rapids SAGD at CNRL Wolf Lake
2003
- NCG injection testing at Cenovus Foster Creek
2001
- solvent SAGD pilot Encana Senlac
2001
- first Athabasca commercial SAGD - Cenovus Foster Creek
1997-1999
- SAGD pilots and demos in Athabasca
1996-1997
- SAGD pilots in Cold Lake
1995
- first SAGD in Saskatchewan - CS Resources Senlac
1993
- first commercial horizontal well CSS - Amoco Primrose
1987
- Underground Test Facility first SAGD test
- vertical CSS carbonates pilot - Buffalo Creek
1980-1986
- Shell Peace River vertical CSS pilot
1978
- Butler et al SAGD patent
1975
- Imperial Cold Lake commercial vertical CSS
1967
- Great Canadian Oil Sands first commercial mine
1965
- Imperial Cold Lake vertical CSS pilots
1926
- Karl Clark hot water separation process patent
1875
- first government sponsored survey
- bitumen used to waterproof canoes
Athabasca Oil Sands Region - Today

BIIP = 1525 Billion bbl

- Grand Rapids: 4%
- Wab-McM mineable: 9%
- Wab-McM in situ: 54%
- Carbonates: 33%

Typical Viscosity > 1,000,000 cp

13 commercial projects all McMurray Formation all SAGD technology

10 pilot/tests - 7 technologies
- Grosmont & Leduc Carbonates
- Grand Rapids, Wabiskaw & McMurray Sandstones

Project Status
- Commercial
- Demonstration
- Pilot Test
31 new commercial projects on-stream by end 2018

8 under construction

18 traditional McMurray SAGD

7 Upper McMurray Wabiskaw SAGD

2 Grosmont CSS

3 Grand Rapids SAGD

1 Solvent Assisted SAGD in McMurray

TAGD pilot planned for Leduc
Why SAGD?

Working with mother nature

SAGD RF = 40-70% (+?)

What matters?
  Pay thickness
  Vertical permeability
  Reservoir quality
  Impairments

Project size

EUR uncertainty
Analogue uncertainty
Classic McMurray Plays

- **Clean Sand**
  - Grade A
  - Grade D

- **IHS**

- **Breccia**
  - Trough cross-bedded sands
  - High energy deposits
  - Clean
  - High angle beds

- **Inclined Heterolithic Strata**
  - Interbedded sand and mud
  - Laterally extensive
  - Characteristic of point bars
  - Potential barrier

- **Breccia**
  - Mudstone floating in bitumen saturated sand
  - Slump – transport facies
  - Baffle not a barrier
Upper McMurray & Wabiskaw

Marginal Marine

A-B Grade  C Grade  D Grade

Generally **thinner & lower permeability**

Less facies variability

No IHS

Wavy beds - bioturbation

Thin shales more likely to be barriers

Tendency towards flat base of pay

Limited performance history

Planned projects are each unique

Commercial - STP McKay
Construction - Sunshine West Ells & Brion MacKay
6 pending projects
Shoreface sand – consistent orientation
Laterally extensive
Clean
Calcite concretions
Bottom water, top lean

Historical Development
CNRL Wolf Lake
Demo
Laricina Germain
Pilots
Cenovus Grand Rapids
BlackPearl BlackRod
Husky Tucker
3 pending projects

Concretion

Bitumen / water contact
Carbonates

BIIP > 400 Billion Bbl

Grosmont, Leduc, Ireton, Nisku Formations

Lower avg porosity

Multiple porosity types

Highly heterogeneous

Data gaps

Matrix drainage uncertainty

Conformance uncertainty

Technology risk

- Grosmont Deposit
- Nisku Deposit
- Leduc Trend
**Grosmont**

**Laricina Saleski Pilot**
Confidential status
Low pressure CSS technology
Cum > 300 Mbbl so far
Sept 2013 rate > 1000 bopd
4D seismic confirms conformance
Commercial development planned

**Operational Pilot**
Laricina Saleski

**Pending Pilots**
Husky Saleski

**Pending Commercial**
Laricina Saleski
OSUM Sepiko Kesik
Thermally Assisted Gravity Drainage - TAGD

Thick, high quality reservoir
Experimental technology
Electrical heating – conduction
Moderate temperatures < SAGD
No steam – negligible water

Operational Proof of Concept Test
Athabasca Dover West
Pending Pilot
Athabasca Dover West
Cold Lake Oil Sands Region

**BIIP** = 183 Billion bbl

- **Wab-McM**: 15%
- **Clearwater**: 32%
- **Grand Rapids**: 53%

**Project Status**
- Commercial
- Demonstration
- Pilot Test

**Typical Viscosity**
100,000 to 300,000 cp

- **5 pending commercial projects**
  - 4/5 SAGD, 2/5 CSS
  - 4/5 Clearwater Formation
  - 1/5 Grand Rapids, 1/5 Lloydminster

- **first in situ commercial development**
- **5 commercial projects** – 1 demo – 1 pilot
- mainly Clearwater Formation
- CSS and SAGD technologies

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Peace River Oil Sands Region

BIIP = 136 Billion bbl

- Shunda: 12%
- Debolt: 36%
- Bluesky-Gething: 51%
- Belloy: 1%

Typical Viscosity: 5,000 to 250,000 cp

4 pending commercial projects
3/4 HCSS, 1/4 Steam Drive
+ 1 pending THAI demo project
+ 1 pending SAGD demo projects

1 demo – 4 pilots
all Bluesky Formation
Horizontal CSS, Steam Drive
Saskatchewan

Smaller scale developments
Typically thinner than McMurray East
Varied depositional settings
Quality varies by project depending on depositional setting
Heavy oil often over bottom water
Streamlined regulatory process & requirements
Generally lower cost developments

Typical Viscosity
5,000 to 50,000 cp

8 commercial – 1 pilot
all Upper Mannville
SAGD & CSS

350-1000 bopd/wp

4 pending SAGD projects
Husky Edam East, Rush Lake, Vawn & Sandall

Senlac
Cumulative SOR

CSOR for Operational Thermal Projects

- McM East
- McM Central
- McM West
- Grand Rapids
- Clearwater
- Bluesky
- Saskatchewan

CSOR values for various projects:
- Cenovus - Christina Lake: 2.0
- Sunoco - Mackay River: 2.4
- Cenovus - Foster Creek: 2.5
- Devon - Jackfish: 2.6
- ConocoPhillips - Surmont: 2.7
- Suncor - Firebag: 3.4
- Cenovus - Wolf Lake McM: 3.5
- Nexen - Long Lake: 3.6
- JACOS - Hangingstone: 3.7
- Deer Creek - Joslyn Creek: 4.0
- Conacher Great Divide: 4.2
- Southern Pacific - Mackay: 4.0
- CNRL - Wolf Lake GR: 4.7
- Black Pearl - Blackrod: 5.5
- Cenovus - Pelican Lake: 5.7
- Husky - Tucker: 7.0
- Imperial Oil - Cold Lake: 7.4
- CNRL - Primrose: 5.4
- Shell - Orion: 4.8
- CNRL - Wolf Lake Clearwater: 5.7
- Husky - Tucker CI: 4.2
- Pennwest - Seal: 1.7
- Baytex - Cliffe Lake: 2.4
- Husky - Paradise Hills: 2.0
- Pengrowth - Lindbergh: 2.0
- Husky - Rush Lake: 2.0
- Husky - Pikes Peak South: 2.6
- Husky - Pikes Peak: 3.1
- Husky - Celtic: 3.1
- Husky - Bolney: 3.4
- Baytex - Kerobert: 4.4
- CPRL - TangleFlats: 5.1

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Pivotal Points

Horizontal wells increase production, decrease capitalization & make SAGD possible

Under Test Facility SAGD pilot demonstrates commercial SAGD production

CVE Foster Creek commercial project

Infill wells in Pad D Foster Creek increase RF & decrease SOR

emSAGP at MEG Christina Lake demonstrates important SOR reduction
Key Innovations

Imperial Cold Lake commercially applies late stage solvent to achieve improved SOR and RF

Modular construction decreases capital

Gas cap re-pressurization to mitigate steam loss, impairment impact

High temperature ESPs evolve to enhance operational flexibility

Enhanced start-up to reduce SOR

Conformance control measures improve performance

Saleski pilot - 1st step to unlocking the carbonates
Looking Forward

Solvent addition to improve rate & recovery, decrease SOR

Infills vs optimized spacing

Stacked pay development

Combining technologies

Reducing the minimum pay economic threshold

TAGD, ESEIEH, NSOLV, etc

Combustion
Technical

- SAGD is new
- Few CSS projects
- No commercial steam drive projects
- Future phases often thinner, lower quality & more impairments
- Future projects target emerging plays & new technologies
- Rapid impactful technology innovation
- Scaling and extrapolating pilot project results
- Estimating effective vertical permeability
- Assessing barriers and baffles
- Estimating SOR
Commodity price
Inflation
Diluent supply and demand
Regulatory impacts
Stakeholder impacts
Development timelines
Execution risks
Reserves Criteria

- Discovered Status
- Established technology
- Positive project economics
- Effectively 100% chance of development
  - Detailed reservoir studies complete
  - Adequate delineation
  - Regulatory approval or no reasonably foreseen impediments
  - Detailed cost estimates
  - Corporate commitment
  - Reasonable development timeline
  - Infrastructure & access to markets, labour and materials
Questions?