In Situ Pad Discussion

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Well Pad Program Director, Major Projects.

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In Situ Pad Discussion

The format that your In Situ development takes depends on many factors that may be unique for your Company, Reserve, Facility, Philosophy and core Competencies.

Where is the industry heading and why?

Who is driving the change?

Is the industry heading in a common direction in spite of these unique aspects?

What are some of the high level items that should be considered when developing a strategic direction?

Let’s have an open discussion to understand the variables and our options.
Why is the Bitumen here?

Middle McMurray Deposits

- Formed dominantly in a mixed tide and wave dominated estuary system.
- Reservoir is composed of amalgamated point bar deposits dominated by fine-medium grained, channel sand. Mud clast breccia is commonly found near the base of the reservoir. The reservoir fines upwards into interbedded sand and mud (sandy and muddy IHS). Thin mud layers are typical towards the top of the reservoir.
Choosing an Alberta Oil & Gas Mega Projects

- **Mine**
  - Environmental pressure, Capital intensive, Labour intensive, Risk/Reward

- **In Situ**
  - Variable capital intensity, Lower capital/barrel, Lower energy intensity, Fungible production

- **Upgraders**
  - Capital intensive, Global bitumen production change, Limited local market
In Situ project cost breakdown

- 30% Central processing facility / 70% Pad costs
- 40% Drilling and completions / 60% Pad facility costs
- 40 to 45% of In Situ project costs are related to pad facilities.
Continuous well pad development

In Situ Well Pad Development
- 10 to 15 year reservoir depletion
- Reservoir characteristics
- Well Spacing and in fill wells
- Technology development
## How do we compare?

<table>
<thead>
<tr>
<th></th>
<th>Suncor Firebag</th>
<th>Suncor MacKay River</th>
<th>Cenovus Foster Creek</th>
<th>ConocoPhillips Surmont</th>
<th>Devon Jackfish</th>
<th>MEG Energy Christina Lake</th>
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<tbody>
<tr>
<td><strong>Approximate Reservoir Depth</strong> <em>approx from logs</em></td>
<td>275-325</td>
<td>95-130</td>
<td>180-225m</td>
<td>305-425m</td>
<td>400m</td>
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<tr>
<td><strong>Well pairs per pad</strong></td>
<td>12-22</td>
<td>9-14</td>
<td>12-13</td>
<td>12</td>
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<td>ESP</td>
<td>ESP, Rod Pumps, PCP’s</td>
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<tr>
<td><strong>Start Up Method</strong></td>
<td>Circulation Bullhead</td>
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<td>Circulation Solvent Soak</td>
<td>Circulation Dilation</td>
<td>Circulation</td>
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Well Pad Costs

A SAGD operation at the Cenovus Christina Lake facility near Lac La Biche, Alta

Pad facility project costs breakdown
- 10% Engineering
- 30% Material
- 50% Labour
- 10% Overhead, other

A SAGD well pad at Suncor's Firebag development helped boost thermal oilsands output to a record in April.
Suncor

Scope development
- Stage of facility; New, Sustaining production, Technology development
- Life cycle plan; Abandon, Relocate, Reuse
- Reservoir characteristics and Technology selection
- Technology centric or Repetitive efficiencies
- Repeatable design philosophy Whole facility or Module components
- Size, Configuration, Components, Complexity
Cenovus

Scope development
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A typical Foster Creek multiwell pad includes nine well pairs. Photo from O&G J 9/6/2010 from Cenovus
Starting off with the end in mind

Contracting strategy
- E,P,C / EP, CM / EPC / others
  - Project structure and contracting strategy to align with corporate capabilities and structure
Starting off with the end in mind

Engineering development
• EP’s size and capability match to owner requirements
• Desired speed of development and project phase overlap
• Industry knowledge, Local capabilities, High values center
• 100% Off shore, what does it look like
• Continuous improvement or Productivity efficiency

• Design once and build many… What does that feel like?
## How do we compare? – Benchmarking Well Pad Design

<table>
<thead>
<tr>
<th></th>
<th>Suncor</th>
<th>MR 750/751</th>
<th>Cenovus</th>
<th>Conoco Phillips</th>
<th>Devon</th>
<th>MEG</th>
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<tr>
<td>Group Separator</td>
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**Legend:**
- C = corrosion
- D = demulsifier
- E = electrical
- FG = fuel gas
- G = glycol
- H = horizontal
- M = methanol
- RD = reverse demulsifier
- S = steam
What are the controllable

Material
- Major components and Tagged items
  - Consistency or low cost option
  - Commercial agreements
  - Design considerations
  - Operations and Maintenance impact
  - Technology development
Where to get the work done

Modulation
- Percentage of modularization
- Location of work
  - Fabrication
  - Assembly
  - Transportation
- Alberta size or Truckable
- Owner managed, Industry capability, 3rd Generation
Where to get the work done
Where to get the work done

Labour
• Field Construction
  • Owner managed, General contractor, Turn key
  • Labour capacity, Travel cards, Temporary foreign workers
  • 3 bids and a buy, Long term relationships,
  • Lump Sum, Time & material, Unit rate
  • Performance and Incentives
Other considerations

- Corporate considerations
  - Standards and Specifications
  - Class of Plant
  - Project Governance

- Technology development, How and when to incorporate
  - ESEIEIH - Enhanced Solvent Extraction Incorporating Electromagnetic Heating
  - Co-Injection
  - Direct Stimulation
  - Gas Lift vs. Mechanical lift
    - End of reservoir life

TECHNOLOGY DEVELOPMENT

COMBUSTION TECHNOLOGY

Wabiskaw
- Air injection pilot June 2006
- 3.0 bcf of gas recovery
- Hosted underlying bitumen
- G1-2010 conventional oil well test
- No contingent resource assigned

Clearwater
- Gas cap air injection for thermal oil recovery (KATCR)
- PA1X 2012
- 117 million oil barrel estimate contingent resources

Note: Supply cost is the average WTI or NWEA price required for an after-tax cost of capital return of 9%.
Source: Cenovus
Operators of in situ oil sands schemes are required to present regular performance reviews to the AER. Resource management reports are required from some operators and, if nonconfidential, are provided here as a separate submission or are incorporated into the performance presentations. Presentations older than what is displayed in the table below, continue to be available through the Information Product Services Section at infoservices@aer.ca.

- **Directive 054**: Performance Presentations, Auditing, and Surveillance of In Situ Oil Sands Schemes
- **Directive 081**: Water Disposal Limits and Reporting Requirements for Thermal In Situ Oil Sands Schemes
- **Thermal In Situ (TIS) Water Publication**

*File size > 50 MB*

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Historical commercial development

The first attempts to develop the Athabasca Oil Sands commercially were made under the assumption that the bitumen in the area must be coming from pools of oil deep beneath the surface. In an attempt to locate these pools, Alfred von Hammerstein drilled the first wells in the region, north of Fort McMurray. Altogether, between 1906 and 1917, about 24 wells were sunk in the search for the mother-lode of oil. None were successful at finding oil, but they did discover salt which became a major industry in the Fort McMurray area for 50 years.

In 1913, Sidney Ells, a young engineer employed by the federal Department of Mines, began his work in the oil sands, which was to last until 1945. Ells was an early advocate of the hot water flotation method of separating bitumen from sand and he conducted a number of experiments to test this technique. He was the first to bring out samples from the area for laboratory testing. As a result, oil sand was shipped to Edmonton to be tested as road paving material. While the paving was successful, oil sand could not compete economically with imported asphalt and the project was dropped.

In the 1920s, entrepreneur R.C. Fitzsimmons used the same hot water flotation process to produce bitumen for roofing and road surfacing at a plant near Bitumount, 80 kilometres north of Fort McMurray. By 1942, however, financial difficulties forced him to sell the operation. In 1948, the plant was taken over by the Alberta Government to investigate extraction methods with large scale equipment.

By 1949, the plant was processing 450 tonnes of oil sand a day, but it was closed because the government was not interested in launching a commercial venture. Data from the experiments was used as the basis for a major study of the viability of commercial production.

Dr. Karl Clark, a scientist with the Alberta Research Council in the 1920s, pioneered experiments with a hot water flotation process which involved mixing oil sand with hot water and aerating the resultant slurry. This would then separate into a floating froth of bitumen and a clean layer of sand which would settle to the bottom of the tank. The hot water flotation method pioneered by Ells, Fitzsimmons and Clark proved, over the years, to be the most viable method of extracting oil from the sand.

In 1936, another developer, Max Ball, founded Abasand Oils Ltd. His plant west of Fort McMurray produced diesel oil from the oil sands. There was a brief flurry of interest in his project, especially during World War II. When the plant burned down after being purchased by the federal government, the project died with the buildings.

The 1950s saw another upsurge of interest in the oil sands when the publication of an Alberta Government report indicated that production from the sand could be a profitable venture.

In 1962, the Government of Alberta announced an oil sands policy to provide for the orderly development of oil sands in such a manner that it would supplement, but not displace, conventional crude oil policy.

The first project off the mark was the Great Canadian Oil Sands (GCOS) Project. GCOS went through a number of ownership changes after its incorporation but, by 1963, prior to the construction decision, ownership rested with the Sun Oil Company (later Suncor Energy). The Suncor project came on stream in 1967 and became the world's first oil sands operation.

In the meantime, the Syncrude consortium was formed in 1964. Syncrude's initial objective was research on the economic and technical feasibility of mining oil from the Athabasca oil sands. Syncrude's proposal for a production facility was finally approved in 1969.

In 1973, construction began on the Syncrude site and, after five years of construction, the first barrel was shipped on July 30, 1978. The official opening of the Syncrude Project was on September 15, 1978. Production steadily increased in the ensuing years and, on April 16, 1998, the billionth barrel was sent down the pipeline, five years ahead of schedule.
Dover Mine Site

UTF showing Tunnels

Mine Dry and #1 Hoist Building

Top of Mine Shaft
Pad Design
Some Foster Creek wedge wells have electrically driven overhead hydraulic pumping units (Weatherford VSH-2 100 hp) while other wedge wells have ESPs. Photo from O&G J 9/6/2010 from Cenovus
SAGD recovery ranges from 50 to 70 percent of oil-in-place.
Devon

A well-pad at the Devon Jackfish In Situ mine site
St Albert Gazette Jul 2010.
A Statoil field worker looks at oil well heads on a well pad at the company’s oil sands operation near Conklin, Alta.
A SAGD well pad at Suncor’s Firebag development helped boost thermal oilsands output to a record in April.
Main Pad:
- 9 WPs
- Process Modules
- Startup Skid Modules
- E&I Skid Modules

Sister Pad:
- 9 WPs
- E&I Skid Modules