31 Ways that THAI is Superior to SAGD

Conrad Ayasse, Ph.D., FCIC

Calgary Winter Club
April 10, 2018

Capri Petroleum Technologies Ltd.,
24, 4807-32 Street, SE, Calgary, Alberta, T2B 2X3
(403) 560-7483
What is SAGD?

SAGD uses parallel horizontal wells separated by 5-meters of bitumen pay. The upper well is a steam injector and the lower well a fluid producer.

Hot native bitumen is heated to enable drainage.
WHAT IS THAI?

Air

Air injector

Hot Rock

Oil, water, gas drainage

Coke fuel

Cap rock

Cold native bitumen

Producer
**What is THAI?**

Toe-to-Heel-Air Injection uses a vertical air injector offset past the toe of a horizontal producer.

A vertical combustion front, made up of previously-deposited coke, provides fuel for the air. Hot combustion gas contacts, heats and partially upgrades the bitumen, which drains with combustion gases into the producer.
Whitesands CONKLIN 4-YEAR PILOT PROJECT WELL LAYOUT

1-3 m bottom water
Pay thickness: **6.5-9.5 m**
Oil rate/well 15 m$^3$/d

Project located in the NE corner of 12-77-9W4
Whitesands Pilot summary

No oxygen to Producer or surface

No corrosion down hole or on surface

Robust, easy to restart
Where is SAGD best used?

It has been said that-
“SAGD is the Perfect Process for the Perfect Reservoir”

These Reservoirs are largely where SAGD has been successful:

Thick, homogeneous, high saturation and high-permeability reservoirs
Where is THAI best used

Whenever SAGD does not qualify from:

Pressure: Reservoir too shallow or too deep
Pay is too thin: 5-15 m
Reservoir quality low: Shale lenses, low So

Or when

Natural gas price is too high
Diluent is too expensive or not available
Pipeline capacity is inadequate
Water not available
Vast majority of Alberta Bitumen is in pay thickness 10-20 m!

Excellent for THAI or Multi-THAI™
1. THAI needs **no ongoing water source**

Only cold air is injected

Water supply is not an issue
2. THAI eliminates ongoing produced water treatment

THAI  Produced water sent to a disposal well or used as SAGD source water

SAGD  Mandated 95% produced water cleanup and recycle

Assume 50,000 bbl/d bitumen:
Water evaporation gas cost is 110 million/y, producing 8,500 tonnes/d CO$_2$
SAGD Produced Water Evaporators are not needed

High energy, high blowdown waste

Connacher Oil & Gas
Great Divide Project,
Ft. McMurray, Alberta, Canada
Approx. 900 gpm 2007

Suncor Firebag Stage 2,
Ft. McMurray, Alberta, Canada,
Approx. 4,200 gpm 2005

Source: SUEZ Water Technologies & Solutions brochure
The price of water evaporation

Assume evaporation energy is 0.5-mscf/bbl water

10,000 b/d oil produces 30,000 bbl/d water

This takes 15,000 mscf methane at $2/mscf or $30,000/d or $11 million/y, producing 785 tonnes/d CO2 or 0.49 tonnes CO2/m3 oil
3. THAI is a net producer of water

Produced water is a mixture of connate water and combustion water from burning the coke.

Combustion water dilutes the salinity of the connate water and makes it eligible as SAGD source water.
THAI Produces SAGD- quality water: Potential sales

<table>
<thead>
<tr>
<th>Calculated Parameters</th>
<th>Units</th>
<th>Whitesands Produced* Water*</th>
<th>SAGD Source Water*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Dissolved Solids</td>
<td>mg/L</td>
<td>6620</td>
<td>6481</td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td>7.64</td>
<td>8.3</td>
</tr>
<tr>
<td>Anions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bicarbonate (HCO$_3$)</td>
<td>mg/L</td>
<td>1610</td>
<td>625</td>
</tr>
<tr>
<td>Carbonate (CO$_3$)</td>
<td>mg/L</td>
<td>&lt;0.5</td>
<td>12</td>
</tr>
<tr>
<td>Dissolved Sulphate (SO$_4$)</td>
<td>mg/L</td>
<td>&lt;0.5</td>
<td>0.3</td>
</tr>
<tr>
<td>Dissolved Chloride (Cl)</td>
<td>mg/L</td>
<td>3630</td>
<td>3420</td>
</tr>
<tr>
<td>Elements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dissolved Sodium (Na)</td>
<td>mg/L</td>
<td>2100</td>
<td>2350</td>
</tr>
<tr>
<td>Dissolved Potassium (K)</td>
<td>mg/L</td>
<td>17</td>
<td>8.6</td>
</tr>
<tr>
<td>Dissolved Calcium (Ca)</td>
<td>mg/L</td>
<td>45</td>
<td>36.8</td>
</tr>
<tr>
<td>Dissolved Magnesium (Mg)</td>
<td>mg/L</td>
<td>22</td>
<td>28.2</td>
</tr>
</tbody>
</table>

* THAI water is Non Corrosive  
* * Devon Jackfish-2 EIA
4. **THAI™** emulsions are easy to break

- No difficult emulsions
- Easy oil/water separation
- Usable water by-product with minimal treatment
- Non-corrosive

**THAI™** Produced Water  
Steam Production water

**THAI™** Wellhead Emulsion  
60 second separation time
5. THAI Generates its own compression energy

For a 10,000 bbl/d plant:

Air compression is the major energy input-
Total power requirement is 2074 GJ/D (24MW)

*Generated by using the energy content of the produced waste gases:
0.21GJ/bbl of produced oil.*

May River expected to generate a **40-45% IRR**
at oil price
US $60/bbl
6. THAI provides its own thermal fuel in situ

SAGD : Purchased natural gas to make steam

THAI : Free energy
Thermal energy from burning the heaviest 9% of the Bitumen at the oil face in the reservoir
7. THAI has better thermal efficiency

Air scavenges the reservoir heat of previous combustion and delivers it to the burning coke at 350 ºC.
<table>
<thead>
<tr>
<th></th>
<th>EFFICIENCY (%</th>
<th>FUEL REQUIRED (Millions BTU)</th>
<th>ENERGY COST ($/Million BTU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam</td>
<td>45-77</td>
<td>1.3-2.2</td>
<td>2.6-4.4</td>
</tr>
<tr>
<td>Air in situ combustion</td>
<td>190</td>
<td>0.5</td>
<td>1.0</td>
</tr>
<tr>
<td>Oxygen in situ combustion</td>
<td>315</td>
<td>0.3</td>
<td>0.6</td>
</tr>
</tbody>
</table>

**OXYGEN combustion is better than STEAM by a factor of 4.3-7.3**

9. THAI has low heat loss to cap rock

SAGD: Large latent heat loss to cap rock
- reduces steam quality at oil face

THAI: Air has no latent heat loss
- scavenges heat from previously heated rock and delivers air to the combustion at 350 °C
10. THAI has lower CO$_2$ emissions

1. Higher thermal efficiency
2. Lower heat losses
3. Scavenges heat from sand
4. No water treatment (Evaporators)
5. Less steel
6. Oil partially upgraded

50 %
11. THAI cannot mobilize water pollutants

Thermal mobilization and the regulatory response:
During the SAGD and CSS process, high-temperature steam is injected into the bitumen-saturated reservoirs to reduce viscosity and facilitate production.

Conduction of heat from the steel casings into surrounding sediments (particularly non-saline aquifers) has been shown to mobilize certain trace constituents (Arsenic) to levels exceeding protective guidelines.

In response, the Alberta Energy Regulator (in conjunction with Alberta Environment and Parks) has developed a policy that will require all in-situ operators (new and existing) to assess the risks of thermal mobilization and address them, as necessary.
To fulfill this requirement, an understanding of site conditions will be required, as well as constituent mobility potential, and attenuating mechanisms.

THAI air is cold so there can be such problems
12. Smaller surface foot-print

Fewer operating units, no water treatment
13. THAI Oil Viscosity Improved

At 20 ºC:

Bitumen 550,000 cP

THAI Oil 4,500 cP

10% of production was in the Secondary Separator at 36 ºAPI
14. API Density of THAI oil Improved 3+ Points

Conklin Average API = 12.5°

Native Bitumen API = 7.8°

Conklin Viscosity = 4,499 cP
THAI Achieves Free in situ Partial Upgrading

In-Situ Upgraded THAI® Oil

Native Bitumen

THAI Condensate 36° API
15. THAI Oil has lower metals

THAI burns the heaviest 9% of the bitumen:

Asphaltenes form coke fuel ahead of the drainage front

Vanadium and Nickel reside in the asphaltenes

Heavy Metals in coke fuel are oxidized and remain in the reservoir

Heavy Metals reduced 18%
16. THAI oil has lower Total Acid Number

**Naphthenic acids reduced 17%**

Catalytic reduction: Hot H2 (to 650 ºC)/reservoir metals

Reaction with alcohols to form esters

Formation of coke removes asplaltenes where acidic components

**TAN Pipeline Penalties reduced**
17. THAI Oil has lower sulphur

Sulphur in THAI oil is 19% lower

Caused by catalytic AQUA-THERMOLYSIS reactions of oil with sub-critical Water and Catalyzed by in situ V and Ni at 400-650 °C
18. THAI produces free hydrogen

3-8% of the Produced gas is Free $\text{H}_2$

At 2 % recovery, a Single producer gives 600 m$^3$/d Hydrogen. Enough to upgrade 35 % of THAI oil to pipeline specifications.
19. THAI oil requires less diluent to pipeline

<table>
<thead>
<tr>
<th>Impact of Reduced Blending Ratio</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Diluent Blending Ratio - SAGD Bitumen</td>
<td>0.30</td>
</tr>
<tr>
<td>Diluent Blending Ratio - THAI® Oil</td>
<td>0.20</td>
</tr>
<tr>
<td>bbl Diluent Saved / bbl Bitumen Blend</td>
<td>0.10</td>
</tr>
</tbody>
</table>

33.3 % DILUENT SAVINGS & INCREASED PIPELINE CAPACITY
Why Upgrade bitumen to pipeline specs?

Financial loses on diluent*

Differential loss on exported Dilbit: USD 5.36/bbl
Transportation to US Gulf Coast USD 5.15/bbl
Total financial loss USD 10.51/bbl

*Altex Energy (internet)
Why Upgrade bitumen to pipeline specs?

Bitumen producers spent CDN 13.3 Billion on diluent in 2016*

Diluent elimination would increase pipeline capacity 30 %*

Partial upgrading of oil sands could fetch additional $10-15 per barrel**

* Alberta Government  
**University of Calgary School of Public Policy
20. THAI oil easy to upgrade to pipeline specs.

Proven in 5-month continuous operation, Demonstrated complete catalyst regeneration

Mild conditions:  
400 ºC, 600 psia, 450-500 H₂ flow/oil flow  
Modest catalyst cost *

*Using CPTL-UG™ catalyst
Upgrading Conklin THAI oil

LHSV 0.9 hr⁻¹

0.6

0.3 hr⁻¹

Catalyst* regeneration

* CPTL-UG Catalyst
## 5-Month Continuous test with CPTL-UG™ Catalyst

<table>
<thead>
<tr>
<th>Property</th>
<th>THAI™ Oil</th>
<th>400 º C, 600 psig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reaction temperature, ºC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LHSV, hr⁻¹</td>
<td>0</td>
<td>0.9  0.6  0.3  0.3</td>
</tr>
<tr>
<td>Time on stream, hrs</td>
<td>0</td>
<td>405  570  850  1181</td>
</tr>
<tr>
<td>H₂ consumption, H₂/Oil, STM m³/m³</td>
<td>0</td>
<td>147  150  175</td>
</tr>
<tr>
<td>Density @ 15ºC</td>
<td></td>
<td>0.9556 0.9382 0.9289 0.9343</td>
</tr>
<tr>
<td>API @15.5ºC</td>
<td>10.5</td>
<td>16  19.3  20.8  19.9</td>
</tr>
<tr>
<td>Viscosity @20ºC</td>
<td><strong>1,898</strong></td>
<td>112  51  24  32</td>
</tr>
<tr>
<td>Mol Wt.</td>
<td>393</td>
<td>289  256  239  255</td>
</tr>
<tr>
<td>Total sulfur, wt %</td>
<td><strong>4.34</strong></td>
<td>2.68  1.26  1.02  1.46</td>
</tr>
<tr>
<td>Conradson Carbon, wt %</td>
<td>11.7</td>
<td>9.64  6.34  5.51  7.40</td>
</tr>
<tr>
<td>Total acid number, mg KOH/g</td>
<td><strong>1.65</strong></td>
<td>0.25  0.21  0.16  0.18</td>
</tr>
<tr>
<td>Bromine number, g/100g</td>
<td>4.78</td>
<td>2.85  1.94  2.85  2.39</td>
</tr>
<tr>
<td>% distillate under 327ºC</td>
<td>36.34</td>
<td>38.99 48.22 55.08 46.86</td>
</tr>
<tr>
<td>Bromine number of distillate, g/100g</td>
<td>13.1</td>
<td>7.32  4.03  5.17  5.10</td>
</tr>
</tbody>
</table>
## 5-Month Continuous test with CPTL Catalyst

<table>
<thead>
<tr>
<th>Reaction temperature, °C</th>
<th>THAI™ oil</th>
<th>400 ° C, 600 psig</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LHSV. Hr-1</td>
<td>0.9</td>
</tr>
<tr>
<td><strong>Heavy metals, ppm</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nickel</td>
<td>61.5</td>
<td>N/A</td>
</tr>
<tr>
<td>Vanadium</td>
<td>160.1</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>SARA analyses, %</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asphaltene</td>
<td>13.9</td>
<td>9.65</td>
</tr>
<tr>
<td>Resin</td>
<td>19.5</td>
<td>15.21</td>
</tr>
<tr>
<td>Aromatics</td>
<td>35.6</td>
<td>32.82</td>
</tr>
<tr>
<td>Saturates</td>
<td>14.6</td>
<td>17.98</td>
</tr>
<tr>
<td>Volatile</td>
<td>16.5</td>
<td>24.34</td>
</tr>
</tbody>
</table>
21. Corporate asset value is increased

Your Bitumen reservoir is actually a heavy oil reservoir!

Higher income 3.50 USD/bbl *

Lower extraction costs 2.00 USD/bbl

Increased NPV 5.50 USD

24 % HIGHER RESOURCE NPV

* THAI diluent savings
22. THAI well costs are lower

Only one horizontal well is needed
23. Steam blowout not possible

THAI air has

High injectivity

even at

low injection pressure
SAGD efficiency is hindered by low-pressure injection
Because of higher viscosities and
the inhibited dilation of the unconsolidated sandstone reservoir
25. THAI can be used in thin (6-15m) reservoirs

SAGD requires substantial bitumen above the steam injector to delay chamber arrival to the cap rock.

THAI was stable, robust and controllable in pay thicknesses of 6.5 and 9.5 meters even with bottom water.
26. THAI can be used in deep reservoirs

Deep reservoirs are at high pressure, so the SAGD steam temperature must be high, which increases heat losses and renders SAGD uneconomical

THAI efficiency does not deteriorate with pressure
27. Better THAI sweep in low quality reservoirs

High THAI temperatures desiccates shale lens barriers

and

Enhances vertical permeability
Oil zone temperatures reach 650 °C
Off-set Observation well Temperatures
Some IHS oil recovery occurs

No change in cap rock temperature

Combustion zone is at > 600 °C

OB well close to the toe of P-1 (Offset laterally 10 m)
28. THAI can be used with lighter oils

Because of its Energy Intensity
(Heating the entire reservoir)
SAGD is not economical for lighter oil recovery

THAI is limited only by the oil
Asphaltenic fuel content
29. Nitrogen in air enables pump-free lifting

...Provided the pay has not been de-pressed by primary production
30. THAI has total microscopic sweep

Everywhere combustion occurs there is no residual oil
31. Lower THAI CAPEX

No steam boilers
No water treatment
Uses vertical injectors
Very simple surface facilities

CAPEX of CAD 350 Million for a 10,000 BOPD plant*

Including Power generation from Produced Gas Combustion and flue gas desulphurization

*May River Project
32. Lower THAI OPEX

- No natural gas for boiling injected or produced water
- Lower heat losses
- No water recycling
- Smaller staffing
- Less diluent

For 10,000 BOPD May River THAI plant
OPEX 6-8 USD/bbl*

* Whitesands estimate
<table>
<thead>
<tr>
<th>Benefit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Fuel cost</td>
<td>No natural gas needed</td>
</tr>
<tr>
<td>No energy costs</td>
<td>Power from Tail Gas combustion</td>
</tr>
<tr>
<td>In situ upgrading</td>
<td>Lower Diluent use, higher oil value</td>
</tr>
<tr>
<td>Lower staffing</td>
<td>Fewer operating units</td>
</tr>
<tr>
<td>No water supply needed</td>
<td>Is a water producer</td>
</tr>
<tr>
<td>Less pollution</td>
<td>Lower CO$_2$, pollutant mobilization</td>
</tr>
<tr>
<td>Broadly applicable</td>
<td>Thinner, dirtier, shallower, deeper</td>
</tr>
</tbody>
</table>

*After start-up*
The THAI Weakness

There is only a SINGLE oil drainage front
so
Only a small part of the horizontal well is in use an any time
and
this limits the oil production rate......

MULTI-THAI™ is the solution
Multi-THAI\textsuperscript{tm} well configuration

Multiple air injectors are placed directly over the producer providing many oil drainage fronts increasing producer utilization and greatly boosting the oil rate
2-Injector Conklin MT (1/2 the reservoir)
Oil Saturation

Growth of the burned chamber is in both directions along the horizontal well

Numerical simulation using the STARS (CMG) Thermal simulator
Multi-THAI\textsuperscript{tm} with 5-Vertical Air Injectors*

10-drainage fronts

*Capri Petroleum Technologies Ltd. Patent CA 2, 698,454 (Ayasse)
### Multi-THAI™ production with 100 km³/d total air

**Spreading the air over the entire producer**

#### Table 2. Numerical simulation results (20-meters of pay)

<table>
<thead>
<tr>
<th>Run number</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td># Air Injectors</td>
<td>1* THAI</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Max. Air per injector, m³/day.well</td>
<td>100k</td>
<td>100k</td>
<td>50k</td>
<td>33.3k</td>
<td>25k</td>
<td>20k</td>
<td>60k</td>
</tr>
<tr>
<td>Max. Total Air injected, m³/day</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>300</td>
</tr>
<tr>
<td>Oil rate after first year, m³/d</td>
<td>28</td>
<td>47</td>
<td>57</td>
<td>68</td>
<td>81</td>
<td>90</td>
<td>156</td>
</tr>
<tr>
<td>Peak oil rate, m³/d</td>
<td>183</td>
<td>141</td>
<td>141</td>
<td>134</td>
<td>130</td>
<td>121</td>
<td>176</td>
</tr>
<tr>
<td>Days to 60% Oil Recovery Factor</td>
<td>2948</td>
<td>2067</td>
<td>2045</td>
<td>2019</td>
<td>1992</td>
<td>1990</td>
<td>1923</td>
</tr>
<tr>
<td>Recovery factor at 30 m³/d oil rate, %</td>
<td>72</td>
<td>77</td>
<td>78</td>
<td>77</td>
<td>77</td>
<td>78</td>
<td>78</td>
</tr>
<tr>
<td>Minimum Cumulative Air/Oil ratio</td>
<td>1291</td>
<td>1023</td>
<td>1021</td>
<td>923</td>
<td>819</td>
<td>764</td>
<td>924</td>
</tr>
</tbody>
</table>
Numerical Simulation Comparison: THAI vs Multi-THAI™

Conklin bitumen (20 m Pay)

- THAI: 1 Injector x 100 km³/d Air
- Total air 100,000 m³/d in each case
3x oil production injecting $O_2/CO_2^*$

50/50 or “Pseudo air”

![Figure 3. Effect of CO2 on oil production rate during THAI(tm) process.](image)

<table>
<thead>
<tr>
<th>Test #</th>
<th>Injection Rate, km³/day</th>
<th>Mol % Oxygen</th>
<th>Mol % CO2</th>
<th>Total Injection Rate, km³/day</th>
<th>Production Rate, km³/day</th>
<th>Produced Gas Mol % CO2</th>
<th>Oil Rate (1-year) m³/day</th>
<th>Cumulative Oil Recovery m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>17.85</td>
<td>0</td>
<td>67.15</td>
<td>21</td>
<td>85</td>
<td>13.1</td>
<td>41</td>
<td>9700</td>
</tr>
<tr>
<td>2</td>
<td>8.93</td>
<td>33.57</td>
<td>0</td>
<td>21</td>
<td>42.5</td>
<td>37.9</td>
<td>54</td>
<td>12780</td>
</tr>
<tr>
<td>3</td>
<td>25</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>25</td>
<td>21.3</td>
<td>47</td>
<td>10078</td>
</tr>
<tr>
<td>4</td>
<td>17.85</td>
<td>67.15</td>
<td>0</td>
<td>21</td>
<td>85</td>
<td>75.0</td>
<td>136</td>
<td>20000</td>
</tr>
<tr>
<td>5</td>
<td>42.5</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>42.5</td>
<td>38.1</td>
<td>57</td>
<td>12704</td>
</tr>
<tr>
<td>6</td>
<td>42.5</td>
<td>42.5</td>
<td>0</td>
<td>50</td>
<td>85</td>
<td>74.2</td>
<td>113</td>
<td>28104</td>
</tr>
<tr>
<td>7</td>
<td>8.93</td>
<td>42.5</td>
<td>33.57</td>
<td>11</td>
<td>85</td>
<td>47.2</td>
<td>70</td>
<td>12000</td>
</tr>
</tbody>
</table>

* Canadian Patent 2,579,854, Ayasse
The Alberta Dream Bitumen Process: MULTI-THAI™

1. Operate Multi-THAI™ for excellent oil rates of > 10.5 °API oil from thin bitumen reservoirs with zero external operating energy. Inject O₂/CO₂.

2. Use CPTL-DO™ to convert H₂S to elemental sulphur* (net energy producer, piloted at Kerrobert, >95% eff.)

3. Upgrade Multi-THAI™ oil to pipeline specifications using CPTL-UG™. (Proven over 5-months)

*Canadian Patents 2,768,359 (Ayasse et al), 2,782,944 (Ayasse et al)
4. Recover hydrogen from produced gas and use CPTL-DO™ waste heat and Tail Gas Combustion waste heat to upgrade MT oil to pipeline specifications

5. Produced gas becomes CO₂ without a separation process: Re-inject some CO₂ along with O₂ and sell the rest
The Alberta Dream Bitumen Process

High oil rates
No Fuel cost
No energy costs
Eliminate diluent use
Water not needed
No GHG emissions
Broadly applicable
Boost pipeline capacity
Access the West Coast

Multi-THAI (O$_2$/CO$_2$)
Burn heaviest 9% of bitumen
Power from Tail Gas combust.
Get higher net back
Is a water producer
Zero CO$_2$ emissions, CO$_2$ sales
Thin, dirty, shallow, deep pay
30-40%
BC objects only to diluent
FREE CO₂

CO₂ sales

Optionally: supplement with electrochemical H₂/O₂

MT oil upgrading

To pipeline

Gas turbine

D.O. H₂S removal

Membrane H₂ recovery

HEX

Hot flue gas (Heat source)

Sulphur

Air

Cryogenic Oxygen

Power

O₂

O₂

CO₂

Multi-THAI injectors

Bitumen

Gas

Oil

Water

Sales or disposal
The Alberta Dream Bitumen Process: PRODUCTS

INTERNAL PRODUCTS
Thermal combustion energy
Electrical power
Hydrogen

EXTERNAL PRODUCTS
Pipeline specification heavy oil
Sulphur
SAGD water
CO$_2$
Thank You!

Any questions?