Oil Sands Development in Canada by SAGD
- Further Challenges to Improve Efficiency -

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Oil Sand and Bitumen

- Canada has the 3rd largest proven crude oil reserves in the world and 165 out of 170 billion bbls is "Bitumen"
- "Bitumen" is extra heavy crude oil in Oil Sand
  - Light components are lost as deposited in shallow area
  - Change of quality by bacteria
Oil Sands Distribution in Canada

Oil Sand is distributed around Fort McMurray north of Alberta. The area is around 140,000 km² (almost 40% of Japan’s land area).
Bitumen Viscosity

Initial Reservoir Condition

Lower Viscosity at higher temperature

Water

Peanut Butter

Honey
Surface Mining and CSS

Applicable to ~75m from Surface (20% of Reserves)

Fracture control is key for success
SAGD (Steam Assisted Gravity Drainage)

- Steam Circulation before SAGD to heat reservoir between Injector and Producer
- Horizontal well pair near the bottom of reservoir
  - Continuous high temperature (>200degC) steam injection from upper well to form a growing ‘steam chamber’
- At the steam-oil interface, steam gives its heat energy to the adjacent oil zone. As a result, steam is condensed to water and oil is mobilized.
- The mixture of oil and water is drained by gravity, not viscous force.
- Typically 2 - 4 bbls of steam is required to produce 1 bbl of bitumen.
Crude bitumen production by SAGD increased 1,000 bpd in 2001 to 933,000 bpd in 2016

131 SAGD projects on operation in 2015 (49 projects under proposal/construction)
JACOS Hangingstone Project Area

Demonstration Project area
(Produced 35 MMbbl in 1999~2016 from 24 well pairs)

Hangingstone Expansion (HE) Project area
- Steam injection from Apr-2017 ~ oil production by SAGD has started from Aug-2017
- CPF capacity: 20,000bpd of bitumen (expandable to 30,000bpd)
- 10,000 bpd bitumen as of Nov-2017 (32 well pairs)
JACOS Hangingstone Expansion (HE) project area
Oil Sands Development by SAGD ~ Challenges for sustainable development

SOR (Steam Oil Ratio) is one of the key parameters
Most of the part is for Water Treatment and Steam Generation
Water Recycle Ratio must be higher than 90%
Reservoir Evaluation - challenge for heterogeneity

- Bitumen flows by Gravity” and drainage area is dictated by steam chamber growth
- Even minor “shale barrier” could significantly affect the steam chamber growth
- Quality Geological Model is required to optimize Development plan (i.e. project economics).
  - Development sequence
  - Well placement & completion
  - Operation strategy
**Reservoir Evaluation - challenge for heterogeneity**

- Steam Distributer enables the steam to be placed at the location, along with rate & quality and helps uniform steam chamber growth
Steam Chamber Pressure Control - Blowdown

• Decrease steam injection pressure with the growth of steam chamber to minimize heat loss and improve SOR (Steam Oil Ratio)
  ➢ Gas Lift / Surface Pump / ESP under 200+ degC
  ➢ Balance of bitumen viscosity increase and heat loss decrease
Steam Chamber Pressure Control – Thief Zone

- There may be water or gas formation contacting to Oil Sands formation (Thief Zone)
- Steam Chamber pressure and/or Thief Zone pressure control to avoid losing steam from Steam Chamber
NCG (Non Condensable Gas) Co-Injection

- CH4 is widely used as Non Condensable Gas (NCG)
- Injected NCG is accumulating at the top of the steam chamber, and it will work as insulation.
- The heat loss from the steam chamber to the overburden will decrease
- Required steam for maintaining steam chamber pressure is reduced and SOR (Steam Oil Ratio) is improved.
Solvent-assisted SAGD (SA-SAGD)

VAPEX (Solvent Only)

SA-SAGD (Solvent + Steam)

- **SAGD** provides high bitumen productivity thanks to latent heat, while steam generation involves high GHG emission.

- **VAPEX** (Vapor Extraction) utilizes solvent instead of steam (very low GHG emission and small foot print), while sole use of solvent results in low bitumen productivity due to slower reaction.

- **Solvent-assisted SAGD (SA-SAGD)**; Steam and Solvent co-injection could exploit the both advantages of SAGD and VAPEX.

[https://www.nsolv.ca/technology/](https://www.nsolv.ca/technology/)
Solvent Diffusion/Dispersion Measurement (JOGMEC Open Lab)

- SOR improvement and Solvent Recovery are crucial key parameters for the success of SA-SAGD
- Diffusion/Dispersion of Solvent is believed to be very important
- JOGMEC and JAPEX are performing joint lab study to measure diffusion of solvent by using CT (JOGMEC Open Lab)
Produced Bitumen on site Upgrading

**Bitumen + Diluent Process**

Steam → Reservoir → Bitumen → Diluent → Diluted Bitumen → P/L

Diluent

Bitumen should be diluted by diluent (condensate) before flowing to Pipeline

**SCWC (Super Critical Water Cracking) Process**

Steam → Reservoir → Bitumen → SCWC (Super Critical Water Cracking) → Synthetic Crude Oil → P/L

Pitch

- SCWC generates SCO (Synesthetic Crude Oil) by partial upgrading with only supercritical water (no diluent, catalyst, H2)
  >> simpler than Full Upgrader
- Transportation cost can be reduced by SCWC thanks to no diluent requirement for transportation

SCWC Pilot Test in Devon, Alberta (JOGMEC/JGC)
Conclusion

• Huge amount of bitumen is reserved in Oil Sands in Canada and SAGD can provide stable bitumen production for decades under optimum development scenario and strategy

• However, steam generation involves higher CAPEX, OPEX and GHG emission compared to conventional resources

• SAGD industry has been challenging number of efforts to improve its efficiency to be economically successful even under recent low oil price environment (this presentation covers only a part of them) and decrease environmental load