Unconventional petroleum: **Oil sands**

Oil sands: Outline

**Extraction**
- Mining
- **In situ**

**Processing**
- Synthetic crude oil
- ‘Dilbit’ / ‘synbit’
- EROEI / Carbon ‘footprint’
Surface ‘strip’ mining used where overburden is relatively thin (near Athabasca River)

Most (80+%) oil sands buried too deeply for surface mining to be economical

Need alternative technique

‘In situ’ extraction techniques

Basic idea: Reduce viscosity of bitumen in oil sands to allow pumping from ‘reservoir’ in conventional sense

Approach: Heat bitumen in situ, typically with steam injection

CSS: Cyclic steam stimulation (‘huff and puff’)
SAGD: Steam assisted gravity drainage
THAI: Toe and heel air injection

Recovery rate:

In-situ techniques: 60-80% of bitumen in place

Surface mining techniques: 95+%
CSS: Cyclic Steam Stimulation

‘Huff and Puff’

Three-phase process

Uses same well

‘Soak’ phase ~ months

SAGD: Steam Assisted Gravity Drainage

Pairs of horizontal wells (vertical separation of 5 – 10 m)

Continuous injection of steam; continuous extraction of bitumen

Steam and volatiles ‘rise’ and form insulating blanket

Bitumen sinks (‘gravity drainage’) and is recovered via lower well
SAGD: Steam (production) power plant
SAGD: Steam injection wells / bitumen extraction wells
SAGD: Slotted well casing

Photo: Robert Johnson

SAGD and Venzuela’s Ultra-heavy Crude Oil

‘Orinoco belt’
THAI: Toe and Heel Air Injection

• Injection well supplies air and water
• Combustion of bitumen in place provides heat to mobilize adjacent bitumen
• Heated (mobile) bitumen extracted
• Combustion front propagates through reservoir

Conventional ‘strip mining’ vs. In-situ production

Compare & contrast (inputs & byproducts)
Oil sands: Outline

Extraction
  Mining
  In situ

Processing
  Synthetic crude oil
  ‘Dilbit’ / ‘synbit’

EROEI / Carbon ‘footprint’

Conventional petroleum vs. bitumen

Conventional refineries process light sweet crude oil (LSCO):
  • Density < 950 kg/m³
  • Low viscosity
  • Sulfur < 0.4%

  • Bitumen:
    Density > 1000 kg/m³
    • ~1000 x more viscous than LSCO
    • 5+% sulfur
    • High concentrations (100+ ppm) of heavy metals, e.g. vanadium and nickel

Bitumen must be ‘upgraded’ or mixed with ‘diluent’
Fate of bitumen from Athabasca oil sands:

- Nearly all bitumen is exported (primarily to United States)
- Cannot pump bitumen through conventional pipelines
- Not economical to ship (truck/train)
- Mix bitumen with ‘diluent’ and transport via pipeline
- ‘Upgrade’ bitumen to synthetic crude oil (‘syncrude’) and transport via pipeline

‘Upgrading’ raw bitumen to ‘syncrude’

Key Point:

**Bitumen** (input) + energy / chemicals = Synthetic crude oil (**Syncrude**) + Byproducts

Image: M.R. Gray, U. Alberta
Mixing bitumen with ‘diluent’

**Goal:** Reduce density and viscosity of bitumen sufficiently to allow transport via pipeline

Approach: Dilute with ‘diluent’

1) **Natural gas condensate** (NGC)
   - End product is ‘dilbit’
   - NGC must be imported (from U.S., typically)

2) **Syncrude**
   - End product is ‘synbit’
   - Synthetic crude (‘upgraded’ bitumen) obtained locally

‘Dilbit’ and ‘synbit’ piped to refineries in U.S.
Movement of crude oil from Canada to United States

Local connection

- 1000 mile, 36" pipeline
- Carries 'dilbit' (diluted bitumen)
- Online Spring 2011
- 450,000 barrels/day

- Parallel pipeline ('Southern Lights') carries 'diluent' (NGL) in the opposite direction

Husky Energy (former Calumet (former Murphy))
Oil Refinery, Superior, WI
Enbridge pipelines

Note expansion into North Dakota

“Sandpiper” pipeline

Keystone XL

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EROEI: Energy returned on energy invested

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Canada pulls out of Kyoto protocol

Ministers argue process does not cover US and China – the two biggest emitters – and that Canada cannot meet targets

- What Canada's withdrawal means

Canada has pulled out of the Kyoto protocol on climate change, one day after an update was agreed on, saying the accord won't work.

The Canadian environment minister, Peter Kent, said Canada was invoking its legal right to withdraw. Kyoto did not represent the way forward for Canada or the world, he said.

Canada, Japan and Russia said last year they would not accept new Kyoto commitments, but Canada is the only country to repudiate it altogether.

The protocol, initially adopted in Kyoto, Japan, in 1997, is aimed at fighting global warming. Canada’s previous Liberal government signed the accord but did little to implement it and current prime minister Stephen Harper’s Conservative government never embraced it.

"The Kyoto protocol does not cover the world’s largest two emitters, the United States and China, and therefore cannot work,” Kent said. “It’s now clear that Kyoto is not the path forward to a global solution to climate change. If anything it’s an impediment.”