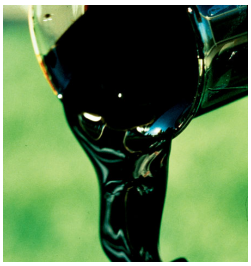
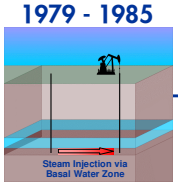
In-situ Technology unlocking Oil sands
- Peace River, Canada

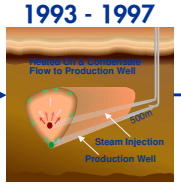


1979 - 1985



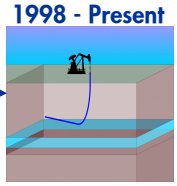
Pressure Cycle
Steam Drive

1993 - 1997



SAGD

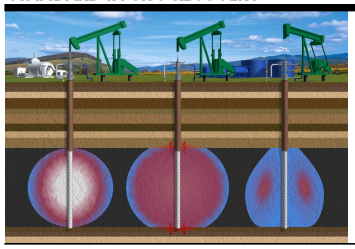
1998 - Present



Cyclic Steam
Simulation

SHELL TECHNOLOGY: IN SITU UPGRADING

STANDARD IN SITU RECOVERY



Produce heavy oil

Combine with diluent

Refinery

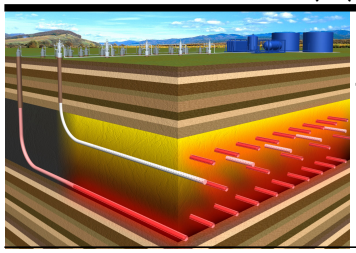
Light products

Coke

SHELL IN SITU UPGRADING PROCESS (IUP)

2004: 8° API

2007: 30 - 49° API



Produce lighter oil

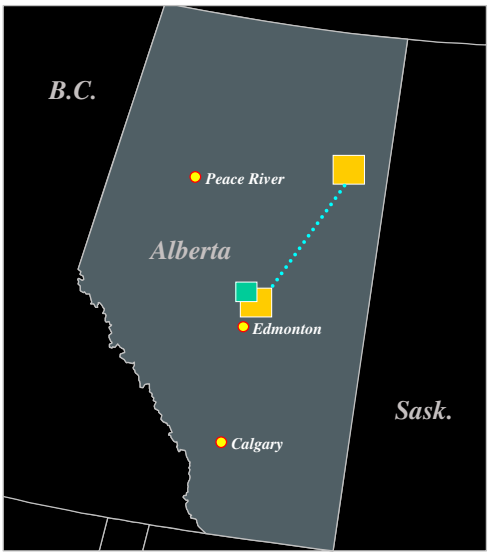
Coke remains in subsurface

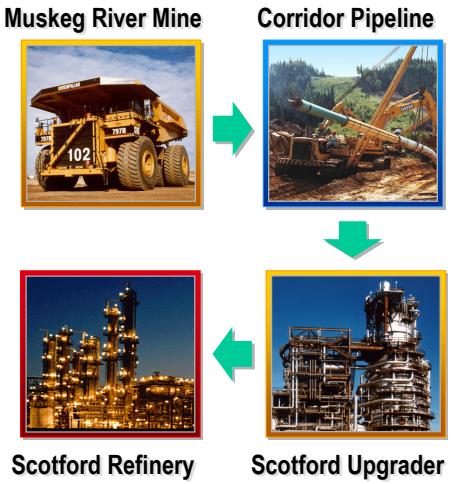
Refinery

Light products

- ✓ More oil recovered
- ✓ Higher quality product
- ✓ Coke left underground

Athabasca Oil Sands Project (AOSP)





Challenges for Heavy Oil

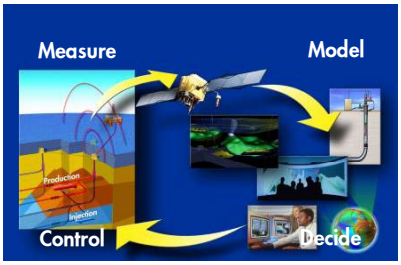
- Heat balance and thus cost and CO2 footprint
- Alternatives

R&D

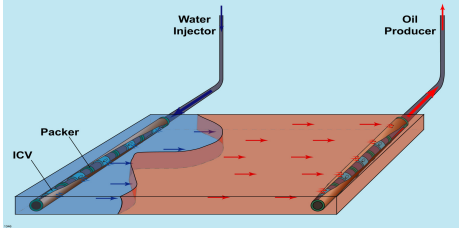
- Solvent addition to steam
- Steam and catalysts
- Chemical means like polymer and emulsion flooding
- Well control and surveillance

WRM + Technology = Improved Recovery

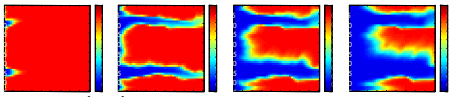
- New monitor/control technology is
  - Increasing reservoir sweep efficiency
  - Increasing ultimate recovery
  - Increasing energy efficiency in facilities
  - Reducing fluid recycling and waste



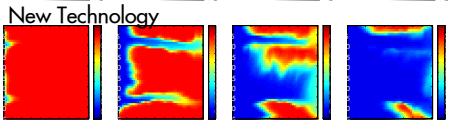
Injector/producer pair



Old Technology



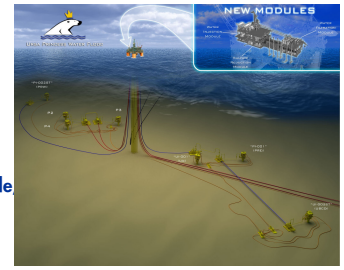
New Technology



=> More Barrels, Less Cost

EOR offshore

- What is different about offshore?
  - Fewer wells/wider spacing → Poorer sweep and higher lag time, engineering of subsea solutions
  - Large volume of chemicals → Huge logistics / supply chain, Weight/space limitations
  - Emulsions are difficult to separate → Large separators, high temperature, Uncertainty
  - Water clean up is a challenge → Discharge restrictions, biodegradable, expansive re-injection



Classical onshore CO2 flood

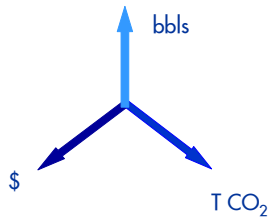
Integrated EOR Project Development

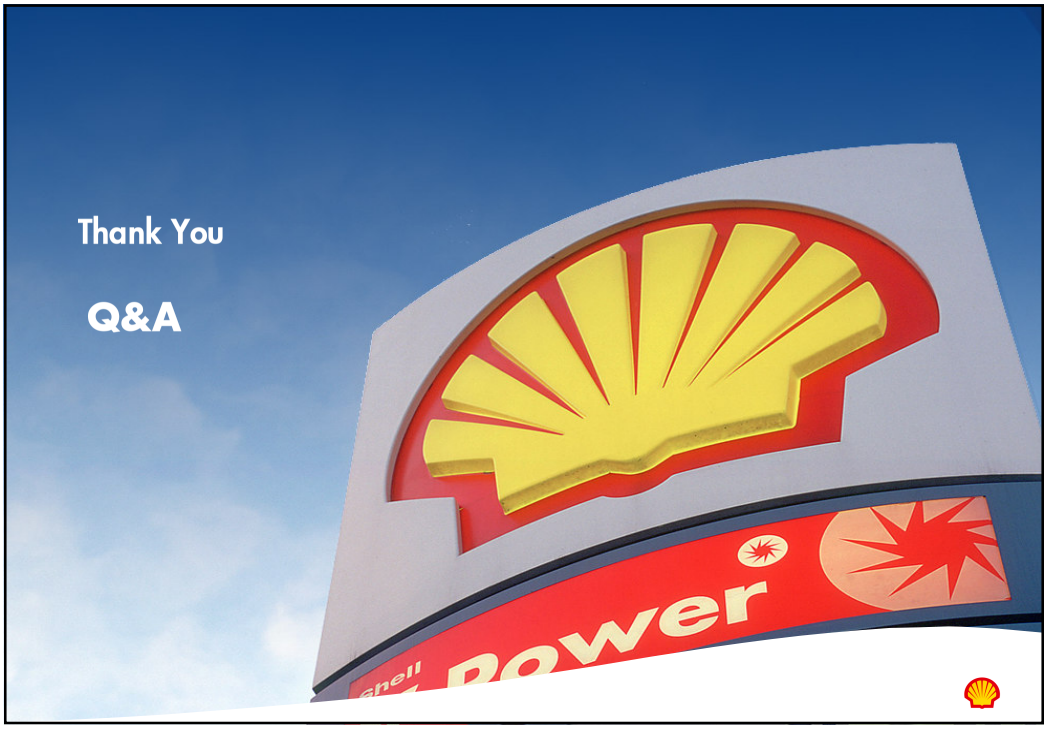
Must understand the cost drivers and how they are impacted by subsurface **AND** surface conditions.

- Cost drivers include:
  - Well count and spacing
  - Injection rate
  - Fluid handling infrastructure
  - Supply and disposal (e.g. water, chemicals, CO2)
- Be prepared:
  - Life cycle considerations: e.g.low-shear WI facilities, CO2 compatible materials
  - Collect enough data up front, do pilots in time
  - Consider the larger picture: e.g. multi-field options, link with power generation

Concluding thoughts

- **The next trillion barrels are there for the taking…but difficult**
- **Yes, its about barrels… but also reducing cost, and managing CO2**
- **Technology can help address all three key drivers (volume, cost, CO2)**
- **And the time is now to develop tomorrow's EOR experts!**




Thank You
Q&A
Power