Extra Heavy Oil and Bitumen

Impact of Technologies on the Recovery Factor

« The Challenges of Enhanced Recovery »

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Heavy Oil Research Leader

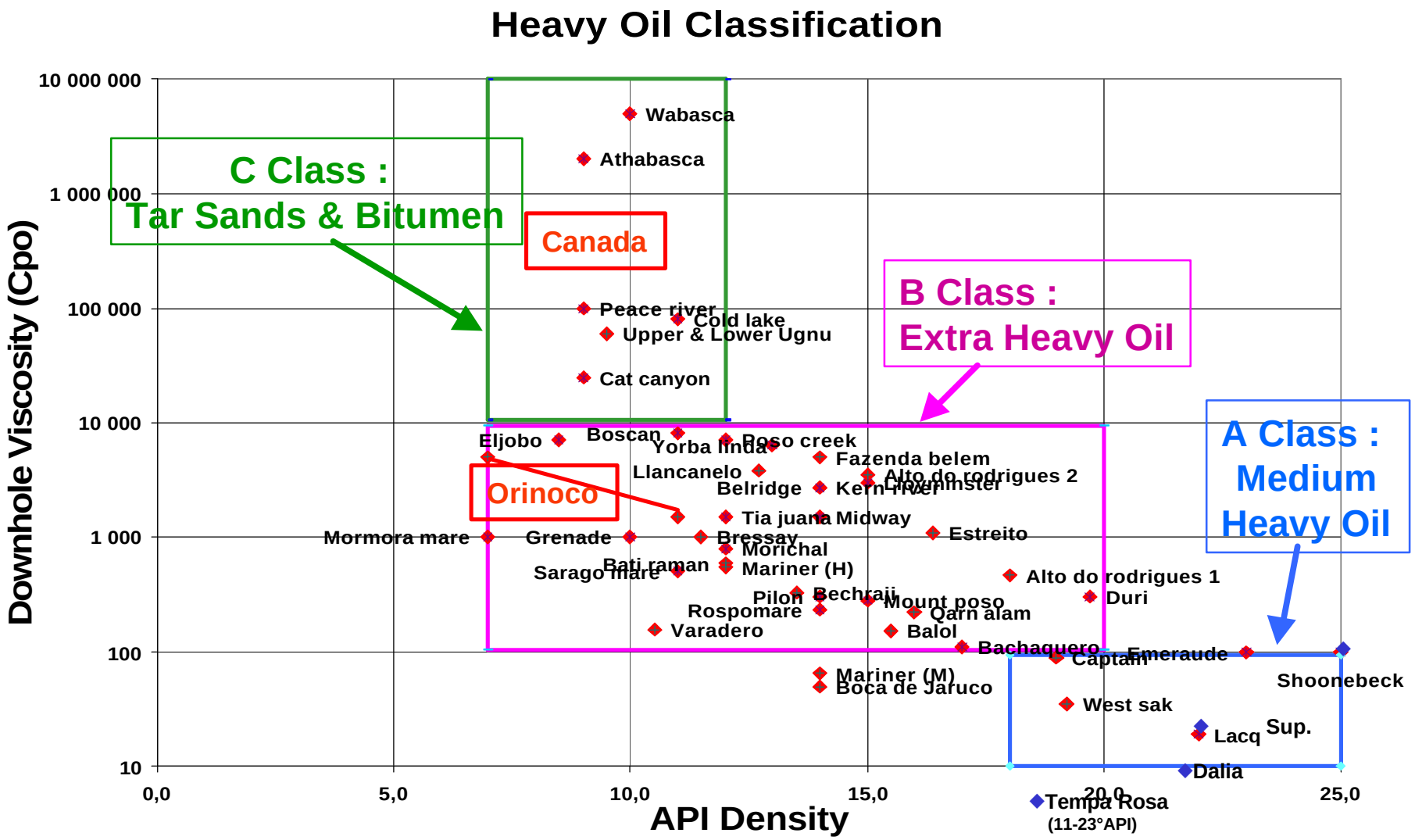
Heavy Oil : a mix of heterogeneous denominations

- **Confusing heterogeneous denominations :**
  - Heavy Oil, Extra Heavy Oil, Oil Sands, Tar Sands, Bitumen, ….
    ➔ ***need for a simple classification***

- **4 Classes based mainly on downhole viscosity :**
  - ***A Class : Medium Heavy Oil*** *25°> d°API > 18°*
    100 cPo >μ > 10 cPo, mobile at reservoir conditions
  - ***B Class : Extra Heavy Oil*** *20°> d°API > 7°*
    10 000 cPo >μ > 100 cPo , mobile at reservoir conditions
  - ***C Class : Tar Sands and Bitumen*** *12°> d°API > 7°*
    μ > 10 000 cPo, non mobile at reservoir conditions
  - ***D Class : Oil Shales***
    Reservoir = Source Rock, no permeability
    Mining Extraction only

TOTAL

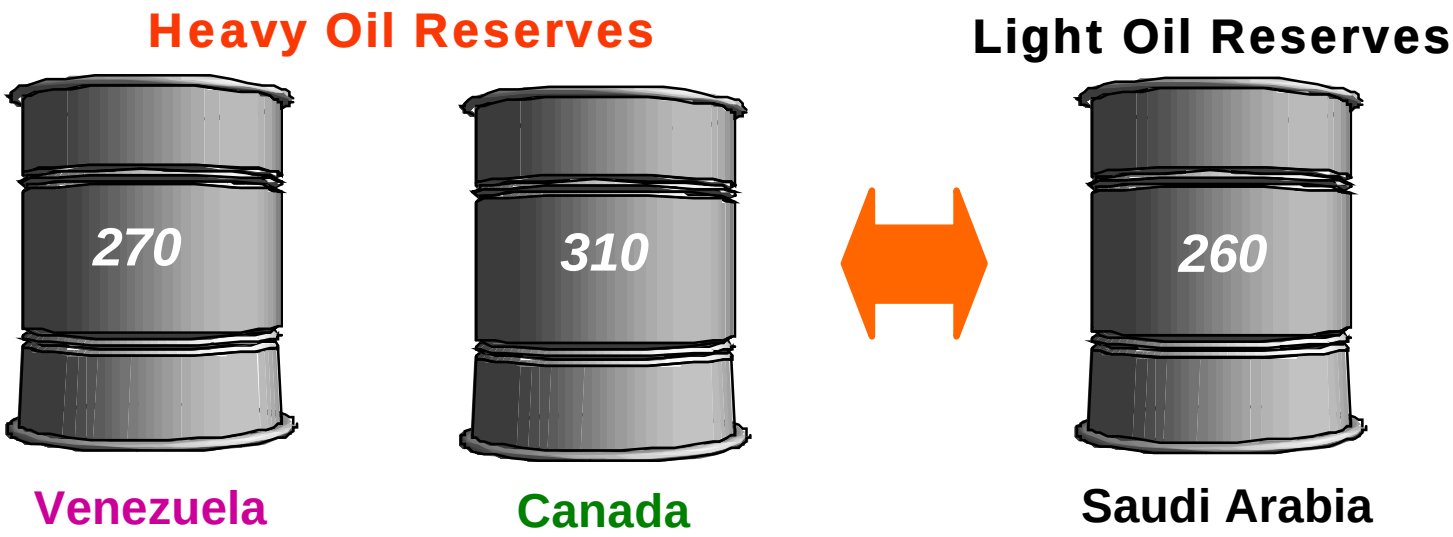
Heavy Oil (excluding Oil Shales) : 3 Main Categories



"Heavy Oils" : Resources of 4000 to 5000 Gb (OIP)

Potential Reserves depends on recovery factors

- **Considerable Potential Reserves : # 500 to 1000 Gb**
  - equivalent to 50-100% of worldwide conventional oil reserves
  - 5 to 10 times (?) the ultra-deep offshore potential reserves
  - mainly (80%) in extra heavy oil, tar sands and bitumens
  - mainly (80%) in North and South America
  - less than 1% produced or under active development

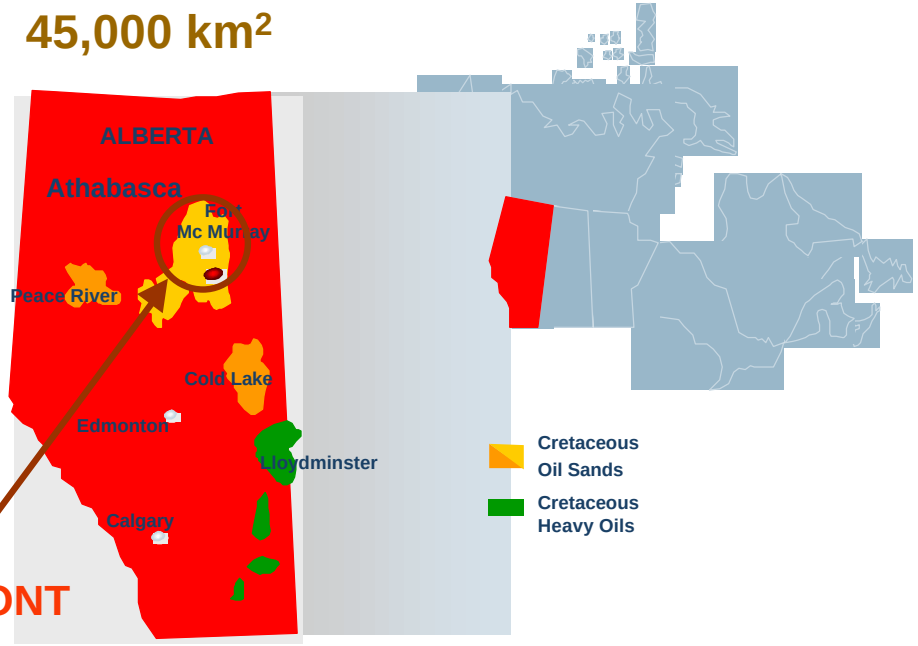


Huge Untapped Resources in Orinoco and Athabasca

54,000 km²

SINCOR OPCO

45,000 km²



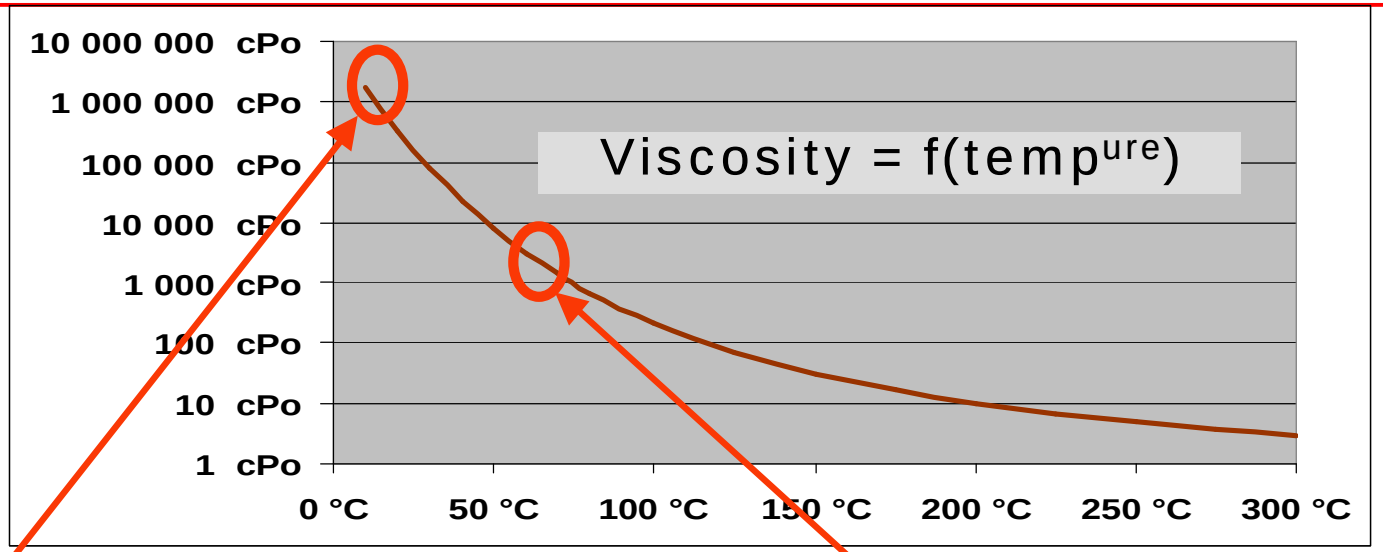
SURMONT

SAGDPilot

Extra Heavy Oils
(μ < 10,000 cPo)
Oil in place: 1,200 Gb
(PDVSA estimates)

Tar Sands & Bitumen
(μ > 10,000 cPo)
Oil in place: 1,300 Gb
(EUB estimates)

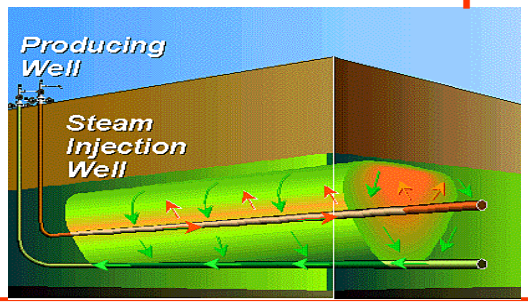
A decisive difference: the geothermal gradient



Athabasca :

- T res. # 11°C
- μ › 1,000, 000 cPo

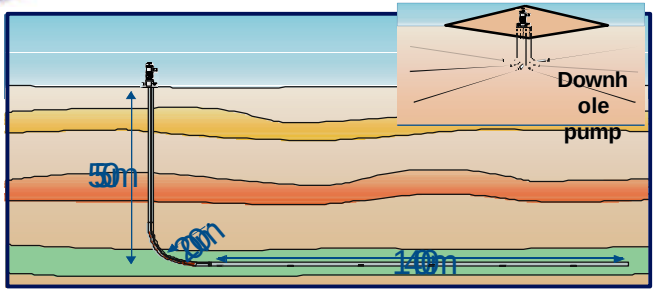
➔ Thermal Production Compulsory



Orinoco :

- T res. # 53°C
- μ # 1,500 to 3,000 cPo

➔ Cold Production Possible



TOTAL

Production Technologies

1 - Proven technologies
… but with limited suitability or recovery efficiency

- Mining Extraction
- Cold Production
- Huff & Puff

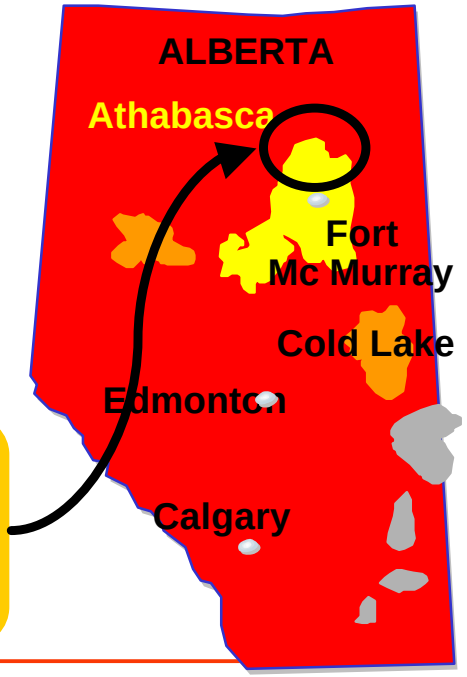
Mining Extraction

- Proven technology
- High Recovery Factor
- Decreasing operating costs :
  - ✓ 1980's : > 25 US$/bbl
  - ✓ 2002 : 8 - 12 US$/bbl
- Limited GHG emissions

BUT :

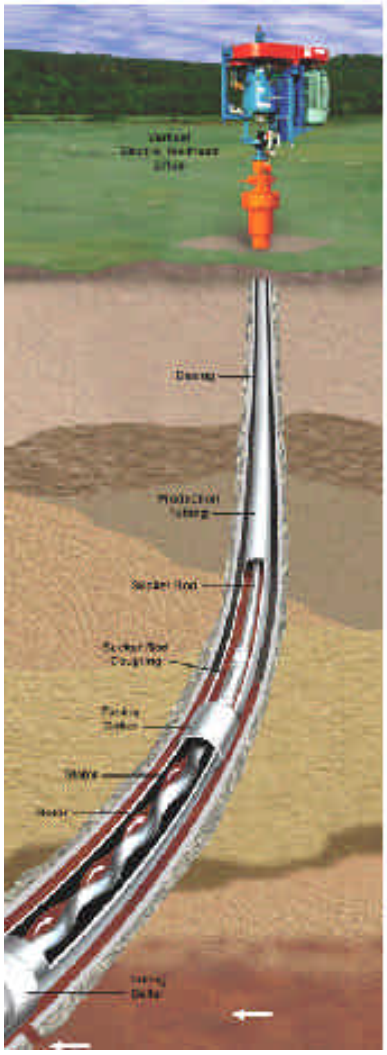
- Overburden limited to 50-75 m

➡ suitable to less than 10% of Oil in Place in Athabasca

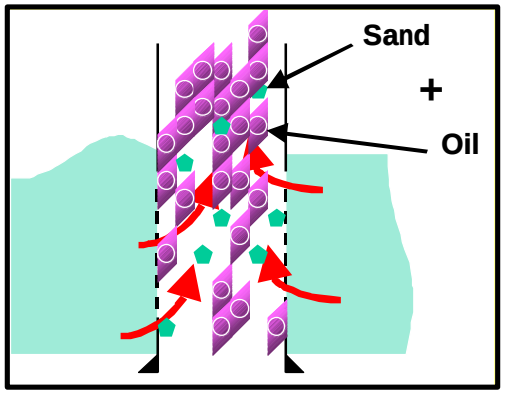


TOTAL

Cold Production



- Proven technology
- Fair productivities with horizontal wells (Venezuela) or with CHOPS (Canada)
- Limited investments
- Limited operating costs (2 to 4 US$/bbl)
- Available artificial lift technologies: PCP, rod pumps
- No GHG emissions



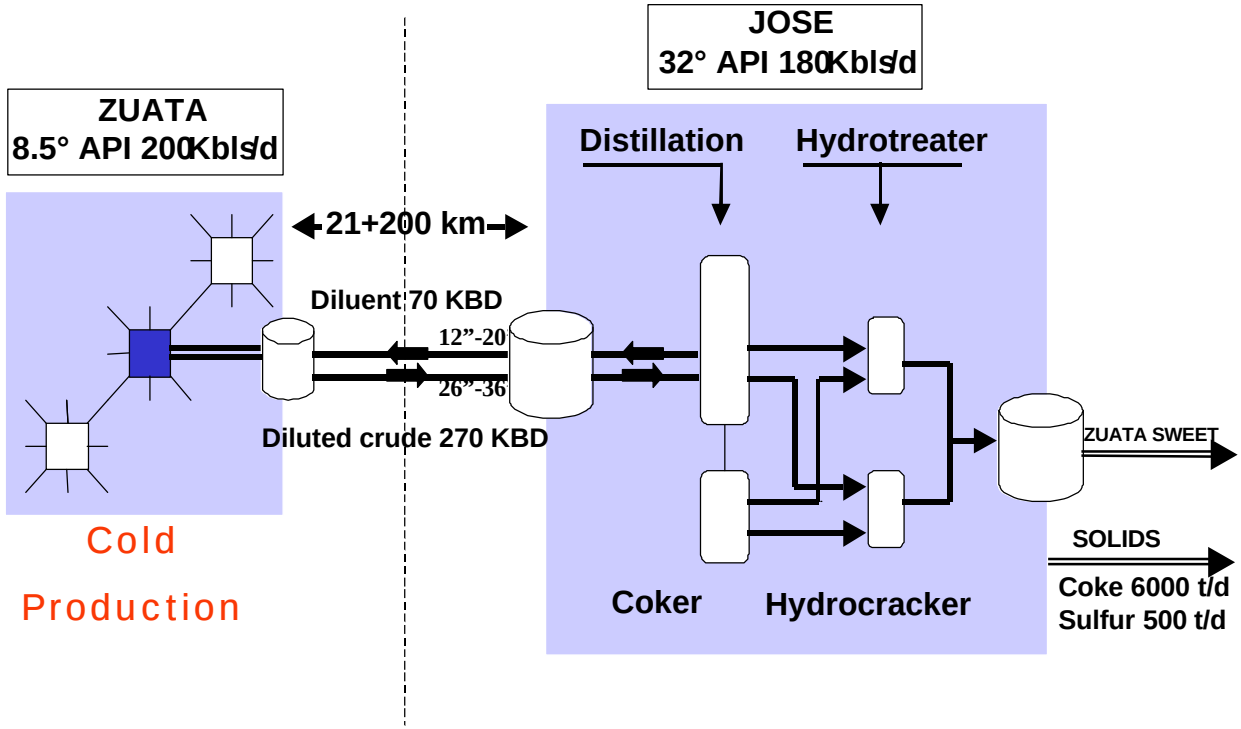
CHOPS

BUT :

- Poor recovery factors (# 5 to 10%)
- Unsuitable for bitumens (too viscous)
- Unsuitable for reservoirs with active aquifer

TOTAL

Example of Cold Production : the Sincor Project



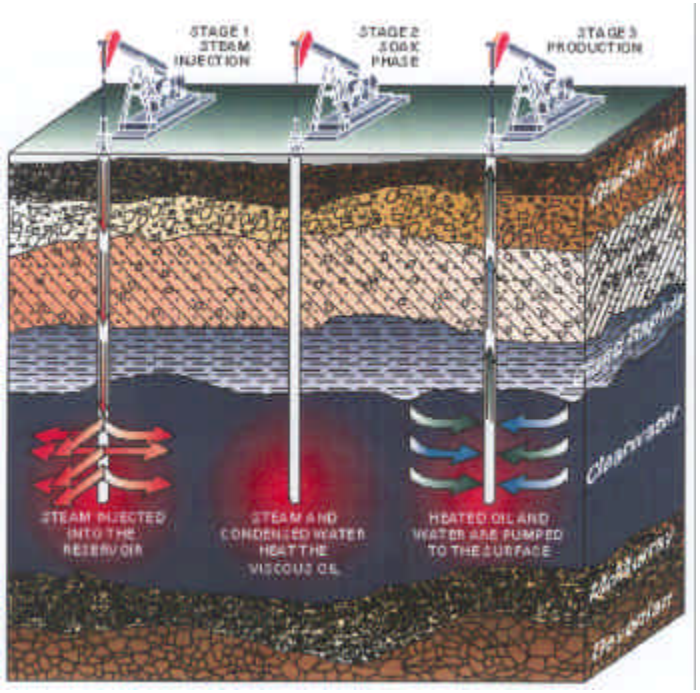
Investment	:	**US$ 4.2 billion**
Plateau production	:	**200 kbd of crude oil**
		180 kbd of Zuata Sweet
Oil gravity	:	**8.5° ⇨ 32° API**
Technical cost	:	**< 7 US$ / b**
Contract duration	:	**35 years**

SINCOR **THE PARTNERS**

TOTAL	47 %
PDVSA	38 %
STATOIL	15 %

TOTAL

Huff & Puff



- **Proven technology :**
  - **Canada : Cold Lake, Wolf Lake & Primrose**
  - **Venezuela : Maracaïbo & Oriente Basins**
  - **California : Kern River**
- **Limited operating costs :**
  - **4 to 5 US$/bbl**

BUT :

- **Limited recovery factors (< 15-20%) : only stimulation around wellbore**
- **Consumption of energy and increase of GHG emissions**

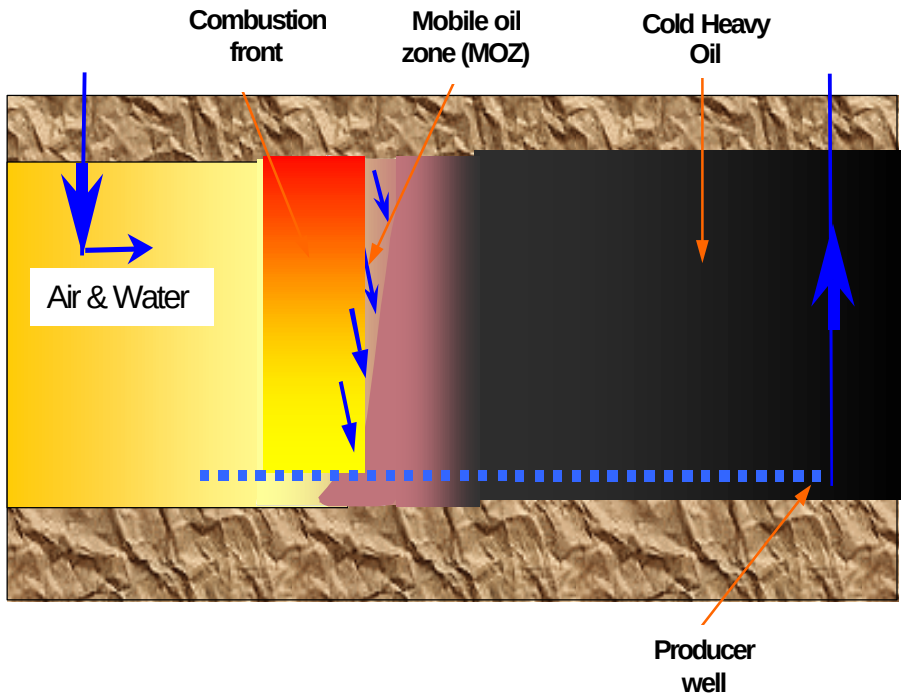
TOTAL

Production Technologies

2 - More efficient technologies
… but not yet field proven

- In-Situ Combustion
- Solvent Injection

In Situ Combustion



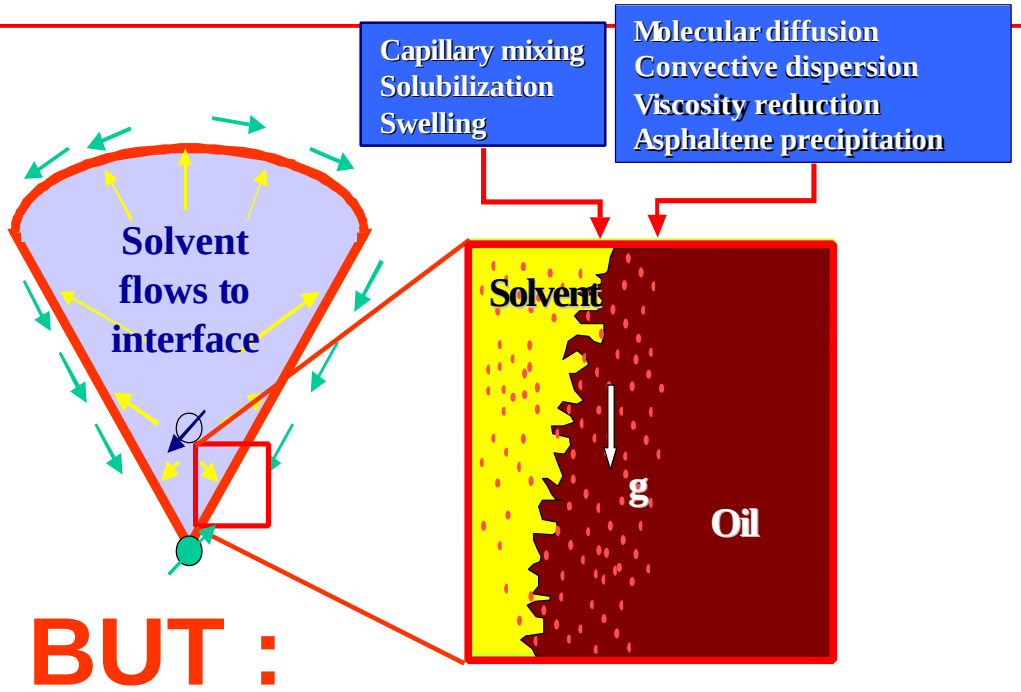
- Old technology (1960's)
- High Recovery Factor :
  - up to 60%
- Self-generation of energy (coke consumption)
- In situ upgrading (thermal cracking)

BUT :

- Field tested nearly exclusively on light oils
- Not so many successes (operational and safety problems)
- Pattern adapted to extra-heavy oil & bitumen to be found and field tested ...

TOTAL

Solvent Injection



- **High Recovery Factor :**
  - **up to 60%**
- **Low energy consumption**
- **In situ upgrading (asphaltene precipitation)**
- **No boiler feedwater treatment**
- **Limited GHG emissions**

BUT :

- **Slow process (molecular diffusivity much smaller than thermal diffusivity)**
- **Start-up not so easy : need for warming with steam ?**
- **Possible "killing factor" : solvent loss in reservoir ?**
- **Not yet field tested : first pilots being launched in Alberta**
- **Not mature enough for industrial application until some years**

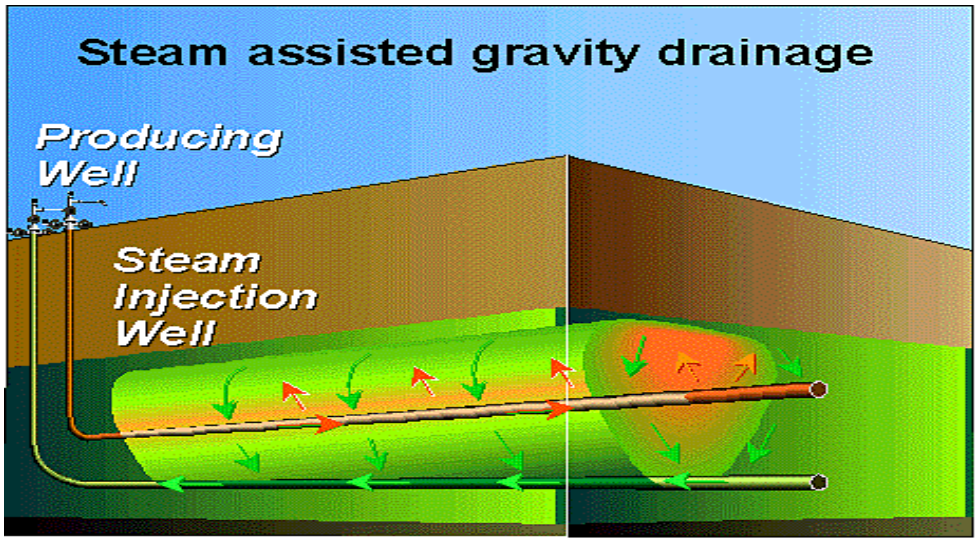
TOTAL

Production Technologies

3 - Available efficient technology
… with proven results

- **Steam Injection and SAGD**

Steam Assisted Gravity Drainage (SAGD)



- **High Recovery Factor :**
  - **up to 60%**
- **Quick process (high thermal diffusivity)**
- **Proven technology :**
  - **several pilots since 1980's in Alberta and elsewhere**
- **Mature enough for medium scale field tests**

BUT :

- **Huge need of energy : 1500 MW for 100,000 bopd !!**
- **"Killing factor" : steam oil ratio (has to be < 3 vol./vol.)**
- **Large GHG emissions : up to 15,000 Tons/day of CO_2 for 100,000 bopd**
- **Requires technics adapted to high temperatures (artificial lift, metering, surface pumping, ...)**

TOTAL

SAGD : already a reality in Alberta

Phase 1 of Foster Creek (EnCana)

Construction of Christina Lake (EnCana)

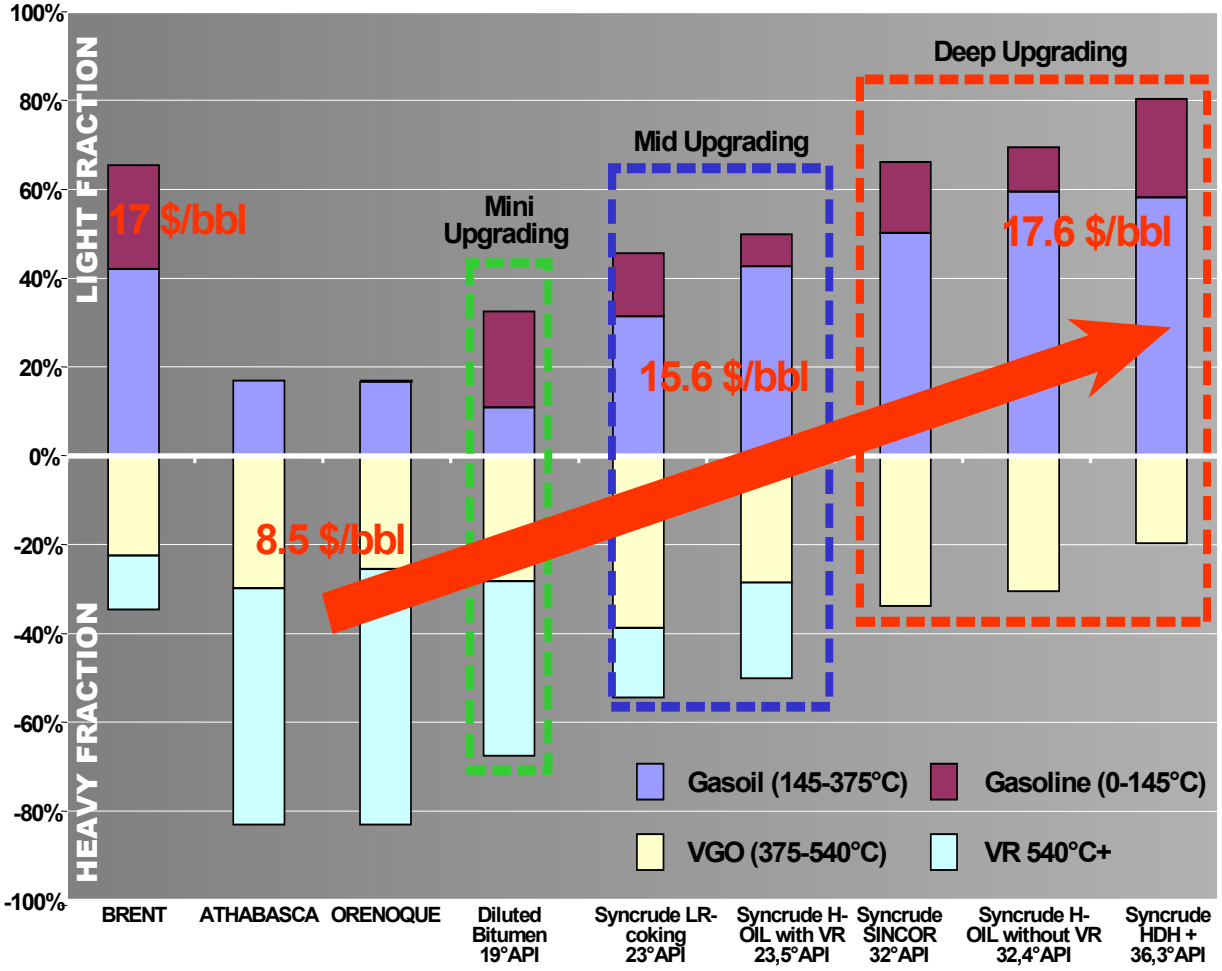
Construction of Mac Kay River (PetroCanada)

Surmont Pilot (Conoco-Phillips / Total / Devon)

TOTAL

SAGD 1st Challenge : To Increase Oil Value

UPGRADING & VALUE OF THE PRODUCT



TOTAL

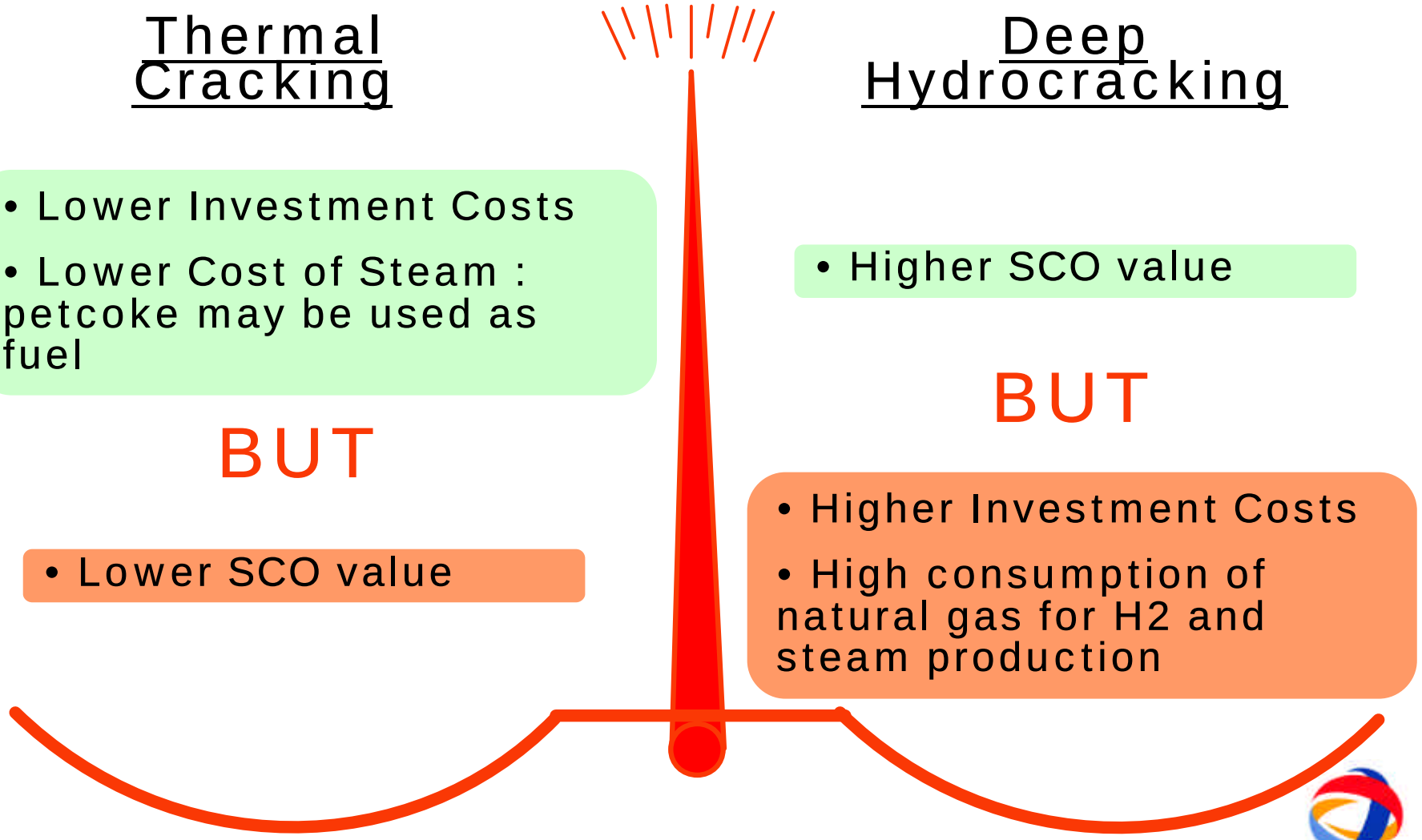
Upgrading : a Balanced Choice

Thermal Cracking

- Lower Investment Costs
- Lower Cost of Steam : petcoke may be used as fuel

BUT

- Lower SCO value



Deep Hydrocracking

- Higher SCO value

BUT

- Higher Investment Costs
- High consumption of natural gas for H2 and steam production

TOTAL

SAGD 2nd Challenge : To Reduce Cost of Steam

Combustion of natural gas :

- **simple and cheap boiler technology (OTSG)**
- **reduced treatment of boiler feedwater**
- **minimized GHG emissions**
- **limited investment costs :**
  - **# 160 MMUS$ (for 100,000 bopd)**

BUT

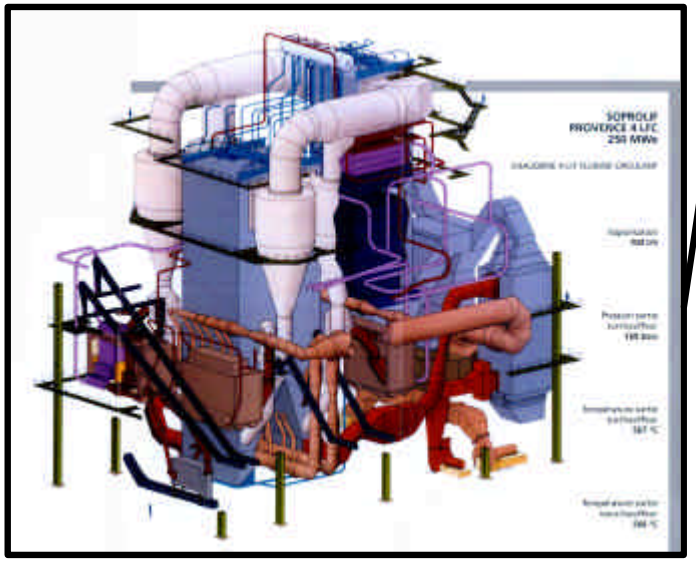
High operating cost :

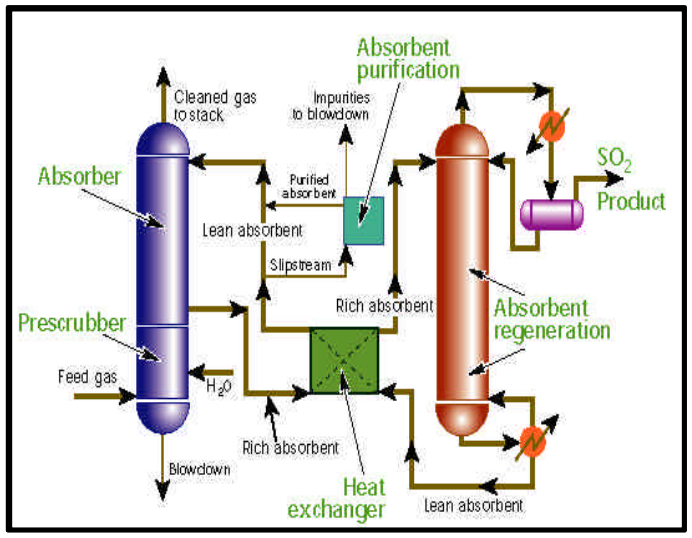
3 US$/Bbl

(gas price ± 3 US$/MMbtu)

TOTAL

1st Alternative Fuel : Combustion of Upgrading Residues





Combustion of residues :

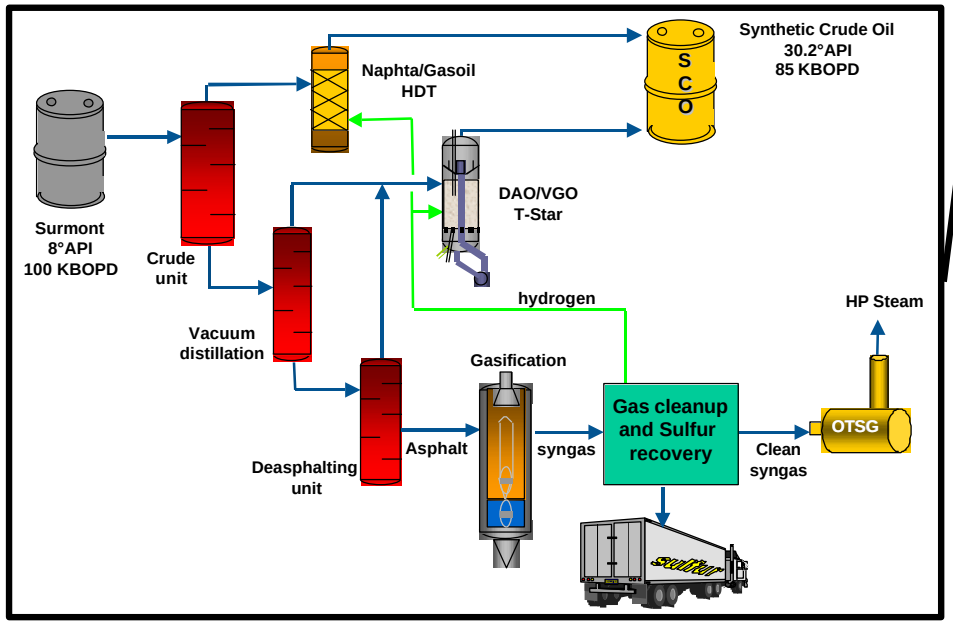
- **cheaper fuel than natural gas :**
- reduced operating cost : 3 ➡ 1 US$/bbl
- **avoids stockpiling of residues (petcoke, asphalts)**

BUT

- Requests specific boilers
- Heavier treatment of boiler feedwater
- High sulphur % ➡ FGD compulsory
- Requires regenerative FGD process to avoid stockpiling of Ca_2SO_4
- Higher CO_2 emissions
- Higher investment costs :
  - 160 ➡ 500 MMUS$ (100,000 bopd)

TOTAL

2nd Alternative Fuel : Gasification of Upgrading Residues



Gasification of residues :

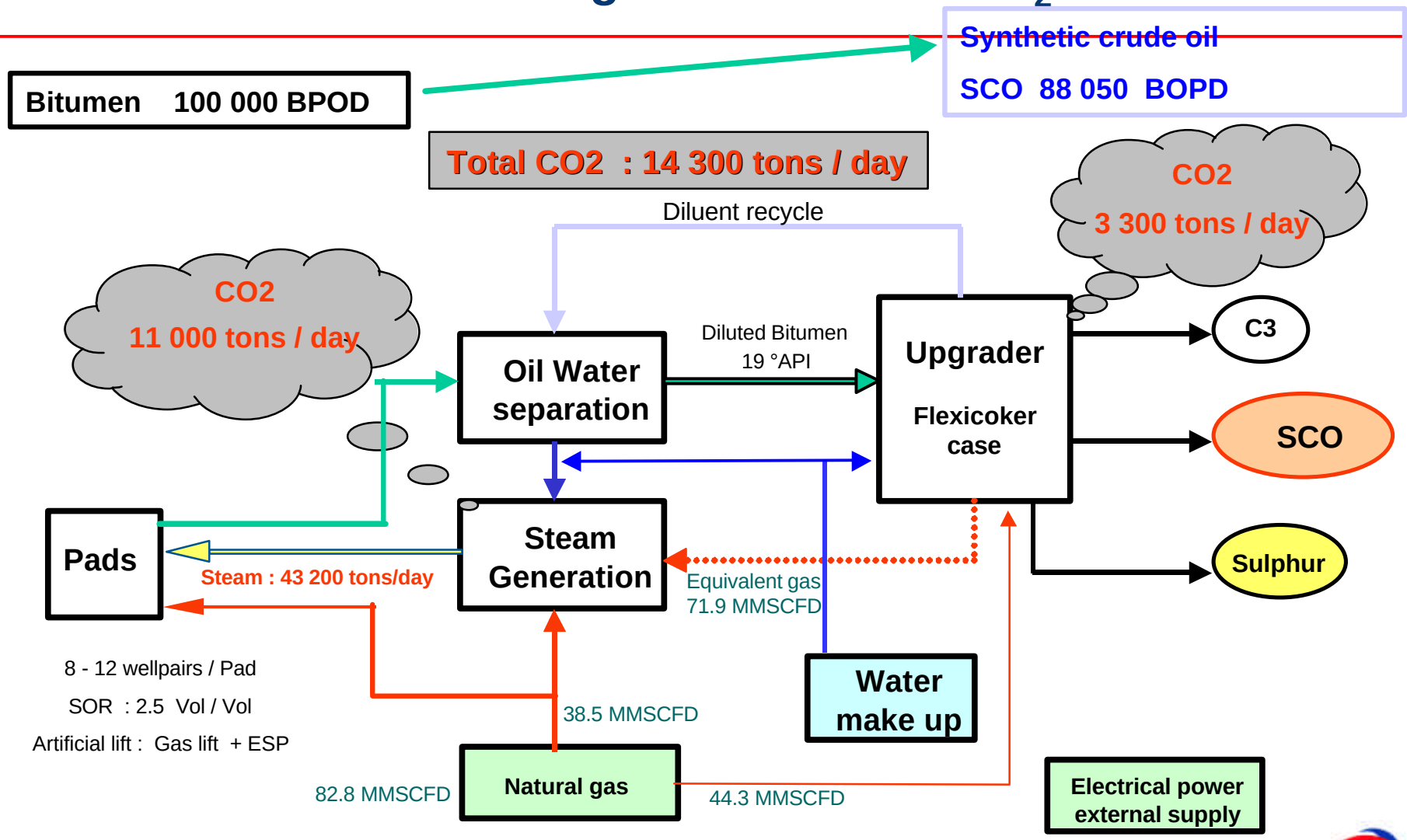
- **cheaper fuel than natural gas**
- **reduced operating cost :**
  3 ➡ 1,3 US$/bbl
- **avoids stockpiling of residues (petcoke, asphalts)**
- **allows production of H_2 for hydrotreatment**
- **easier capture of SO_2 and CO_2**
- **syngas can be burnt into simple OTSG boilers**
- **reduced treatment of boiler feedwater**

BUT

- Higher investments costs :
  - 160 ➡ 360 MMUS$ (100,000 bopd)

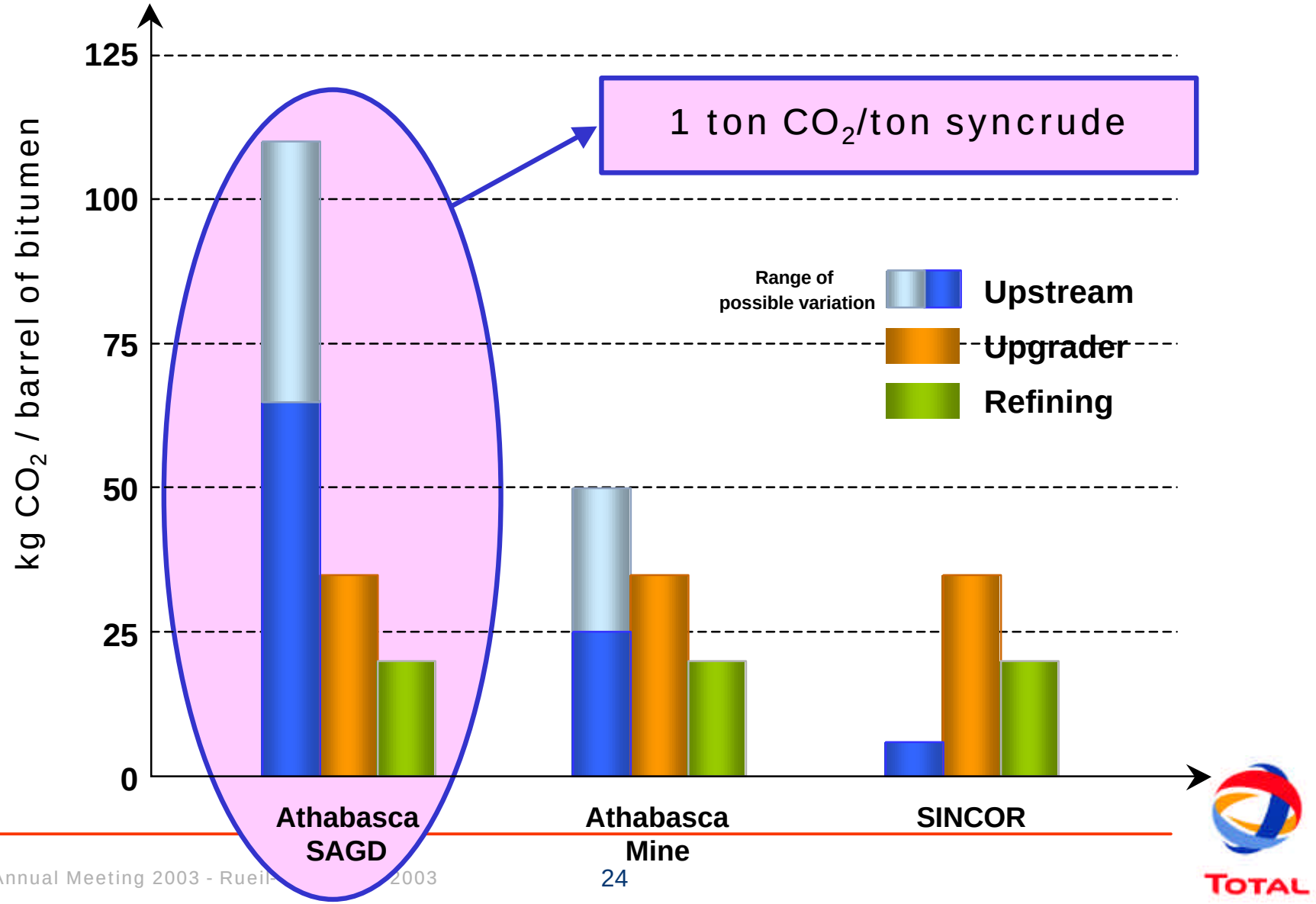
TOTAL

SAGD 3rd Challenge : To Reduce CO_2 Emisions



Nota : CO2 for bitumen production with only Natural gas : 6 500 tons / day

CO_2 Emissions in SAGD



Cost of CO_2 Capture

Today solution : MEA process

technical capture cost # 25 US$/T CO_2

+ 0,5 T CO_2 emission / T CO_2 captured

➡ real capture cost # 50 US$/T CO_2

➡ **+ 10 US$/bbl !!**

?

Tax ?

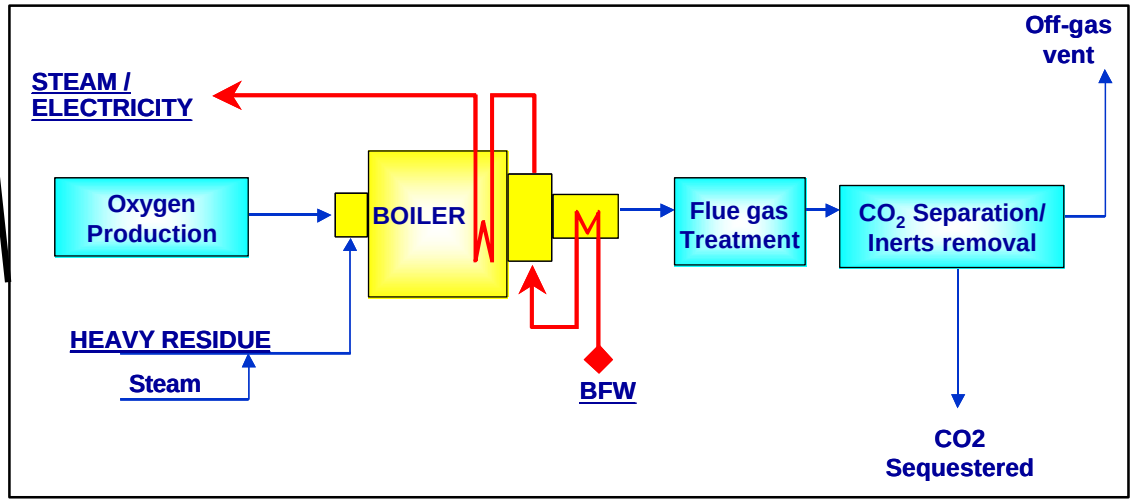
10 US$/T CO_2 ? ➡ + 2 US$/bbl

20 US$/T CO_2 ? ➡ + 4 US$/bbl

30 US$/T CO_2 ? ➡ + 6 US$/bbl

Possible solution : oxy-combustion

(concentration of CO_2)



TOTAL

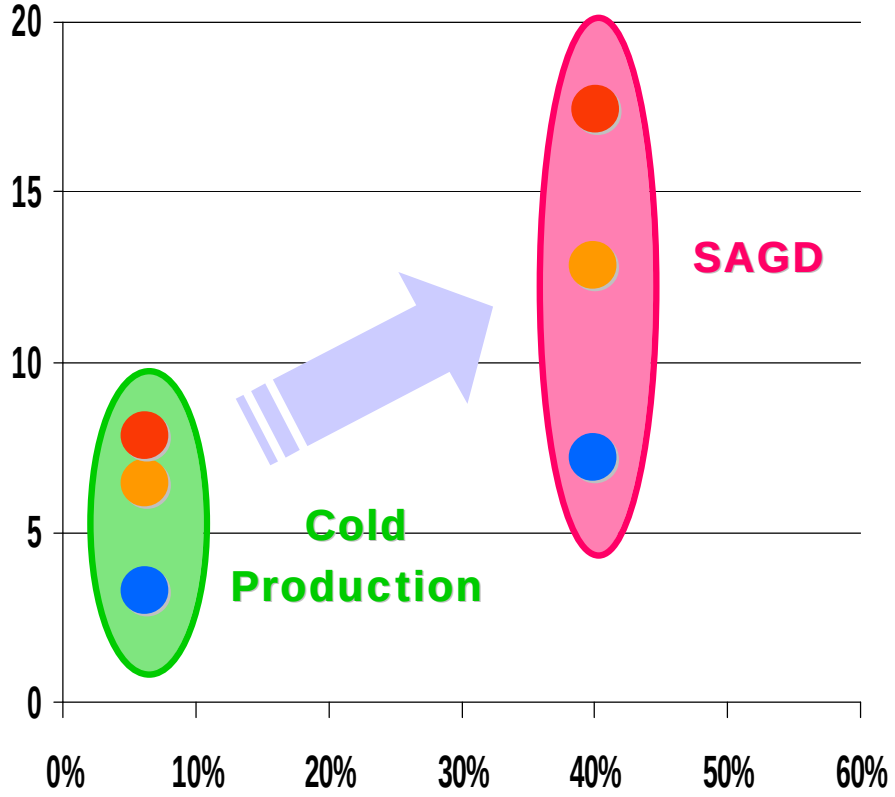
Conclusion : Impact of Recovery Efficiency

Upstream + Downstream + 20 $/T CO_2 tax

Upstream + Downstream

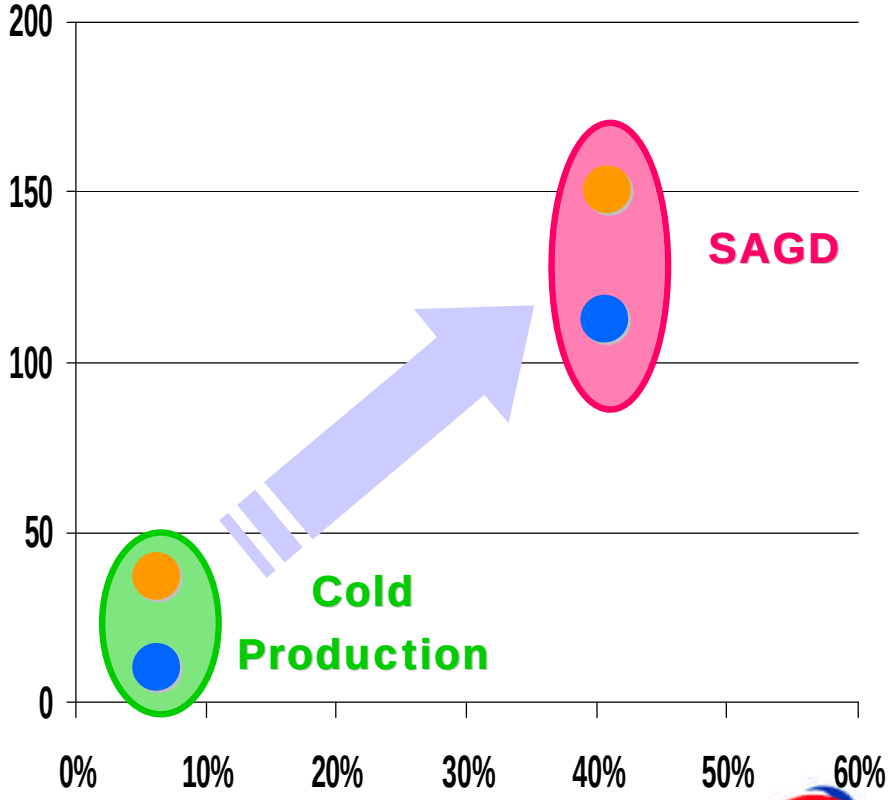
Upstream only (no upgrading)

Technical cost (US$/bbl)



Recovery Efficiency

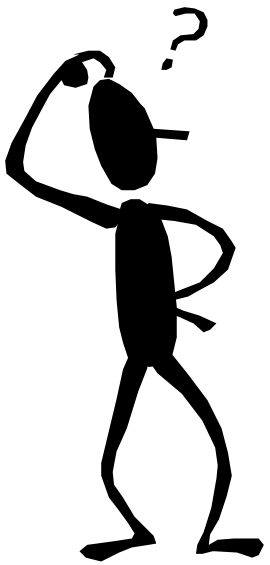
CO_2 Emissions (kg/bbl)



Recovery Efficiency

TOTAL

Conclusion



Difficult choice between :

- current proven technologies :
  - ✓ limited costs and GHG emissions
  - ✓ limited recovery factor (10% max?)
- emerging “hot” technologies :
  - ✓ higher recovery factor (40%+?)
  - ✓ but : higher cost and higher GHG emissions

➡ A temptation:

✓Nuclear Energy to produce steam?

✓But not without drawbacks (especially beyond technology)

TOTAL

The End

Thank you for your attention.