

Enhanced Oil Recovery for Conventional Resources

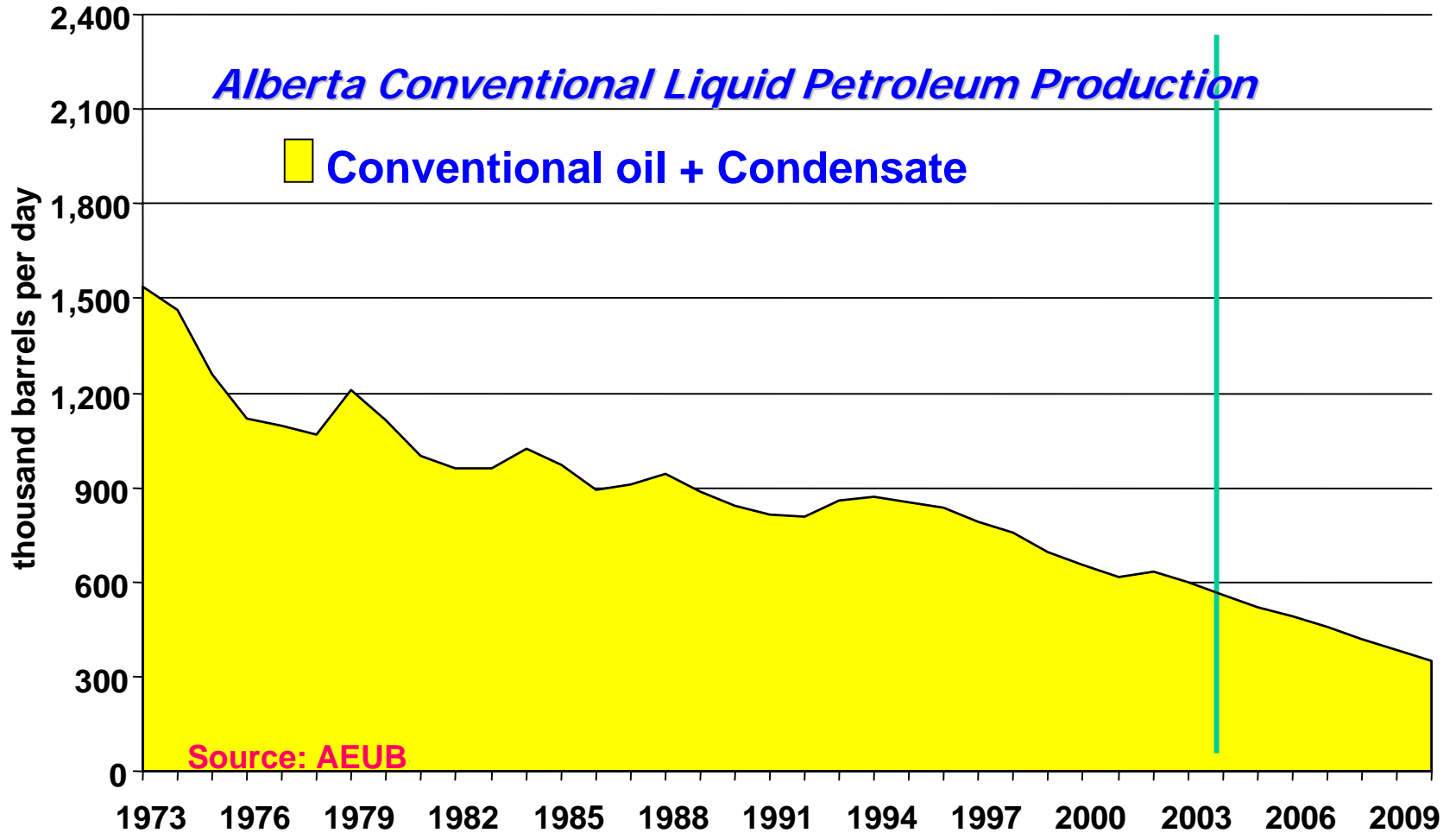
Economics Society of Calgary

June 15th, 2005

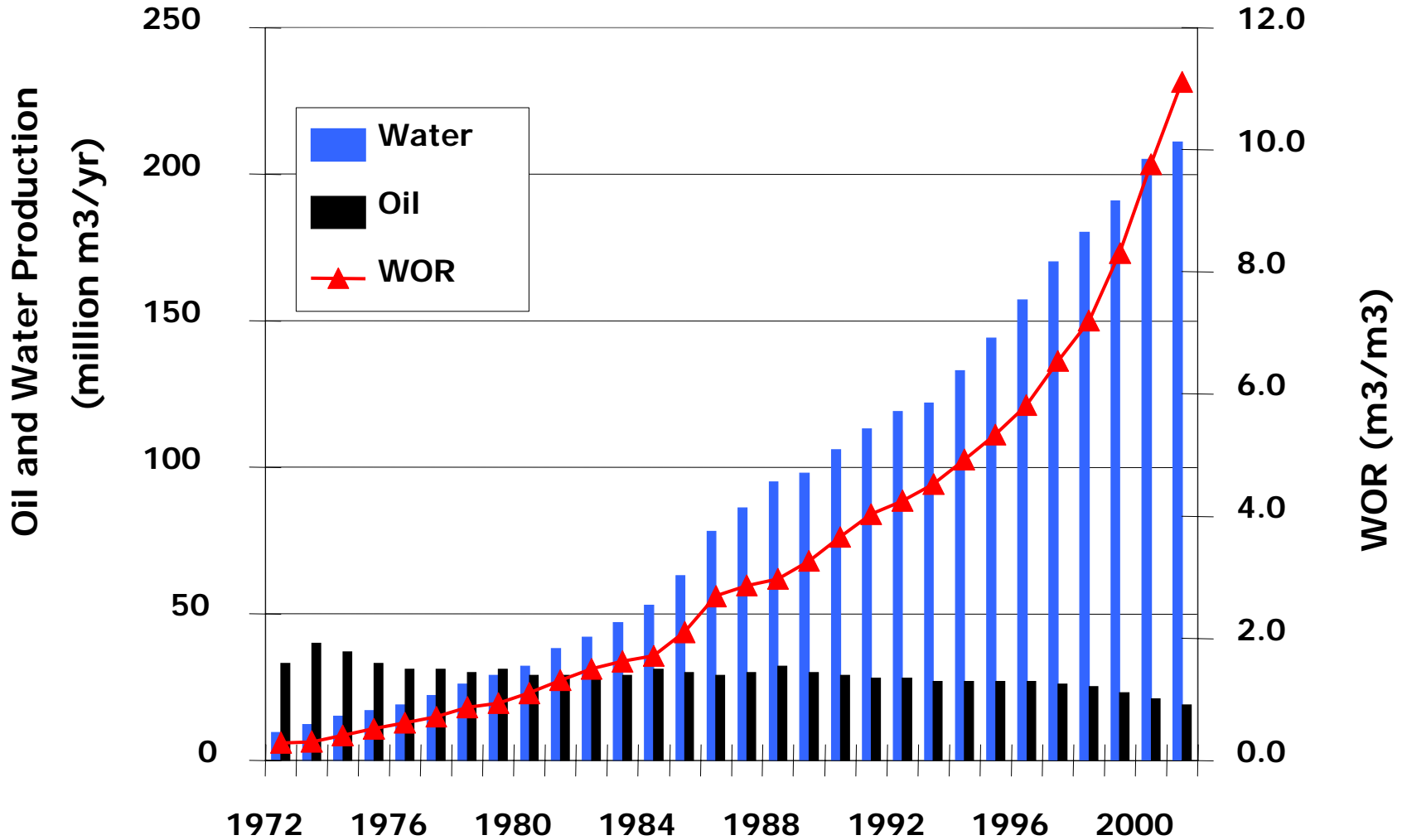
***Eddy Isaacs, Managing Director
Alberta Energy Research Institute***

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Alberta Conventional Production Reached Peak in 1973



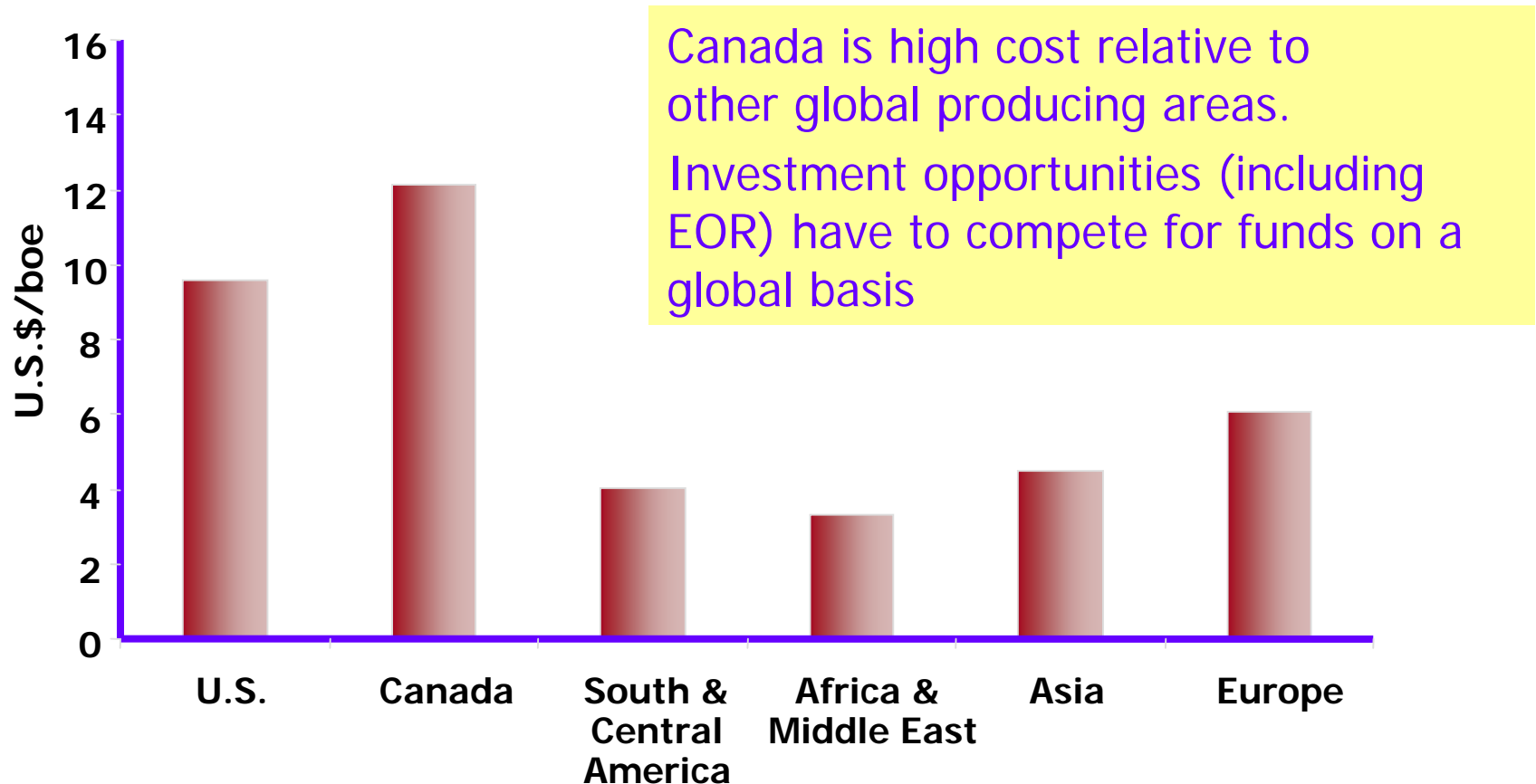
Alberta Water and Oil Production



AEUB Data

Courtesy: Bruce Peachey, 2005

Global Finding & Development Costs 2001



Source: John S. Herold Inc.
Courtesy: CAPP

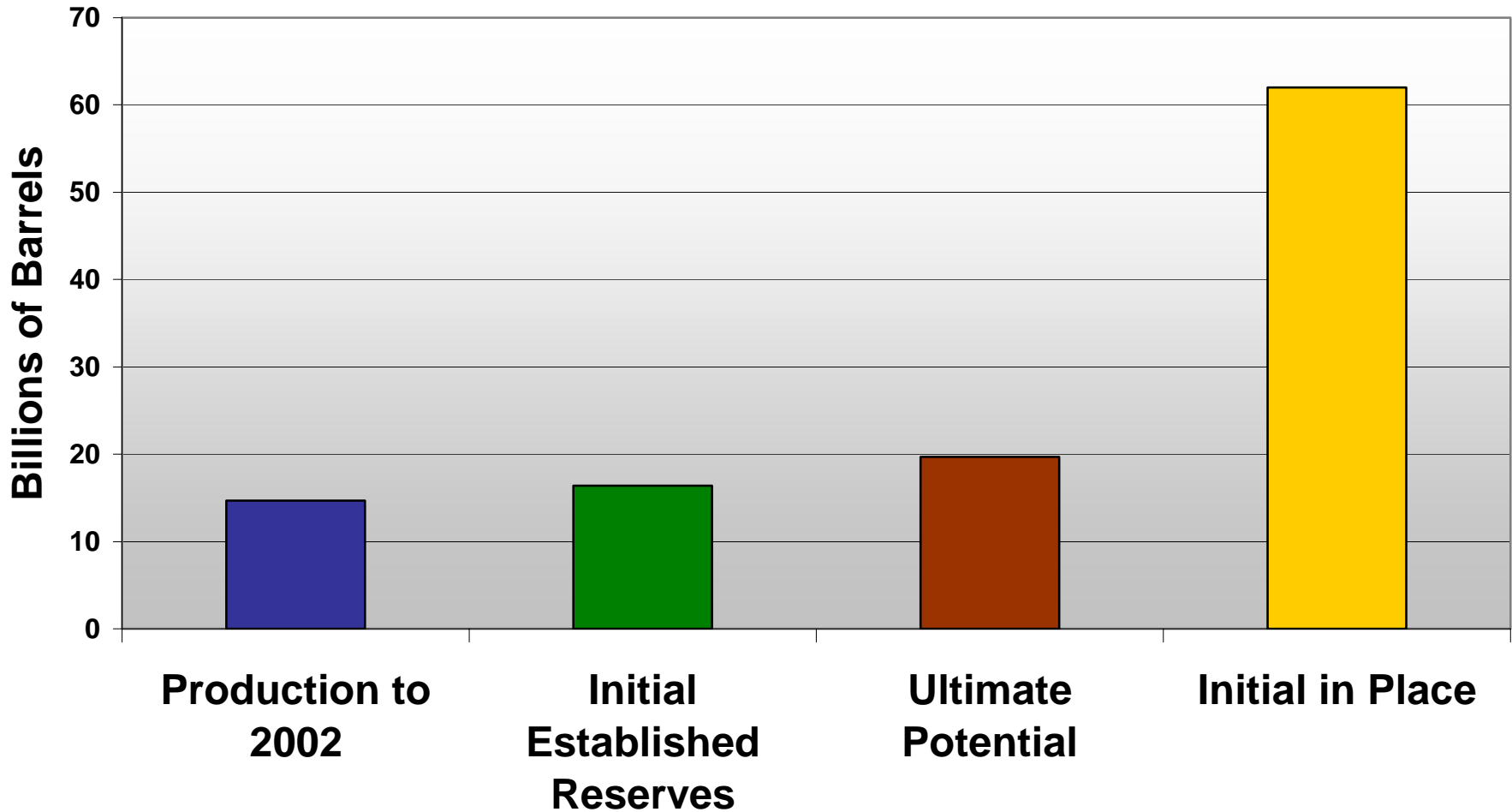
Current Trends

- WCSB mature for conventional oil (increasing costs)
- The environment for a conventional oil producer is uncertain and risky
- WCSB emphasis shifted to production growth for bitumen
 - ❑ Technology has been a major contributor
- EOR difficult technical game
 - ❑ in-house “smarts” to play
- R&D collaboration is limited

Despite risks, the future has lots of promise and significant opportunity

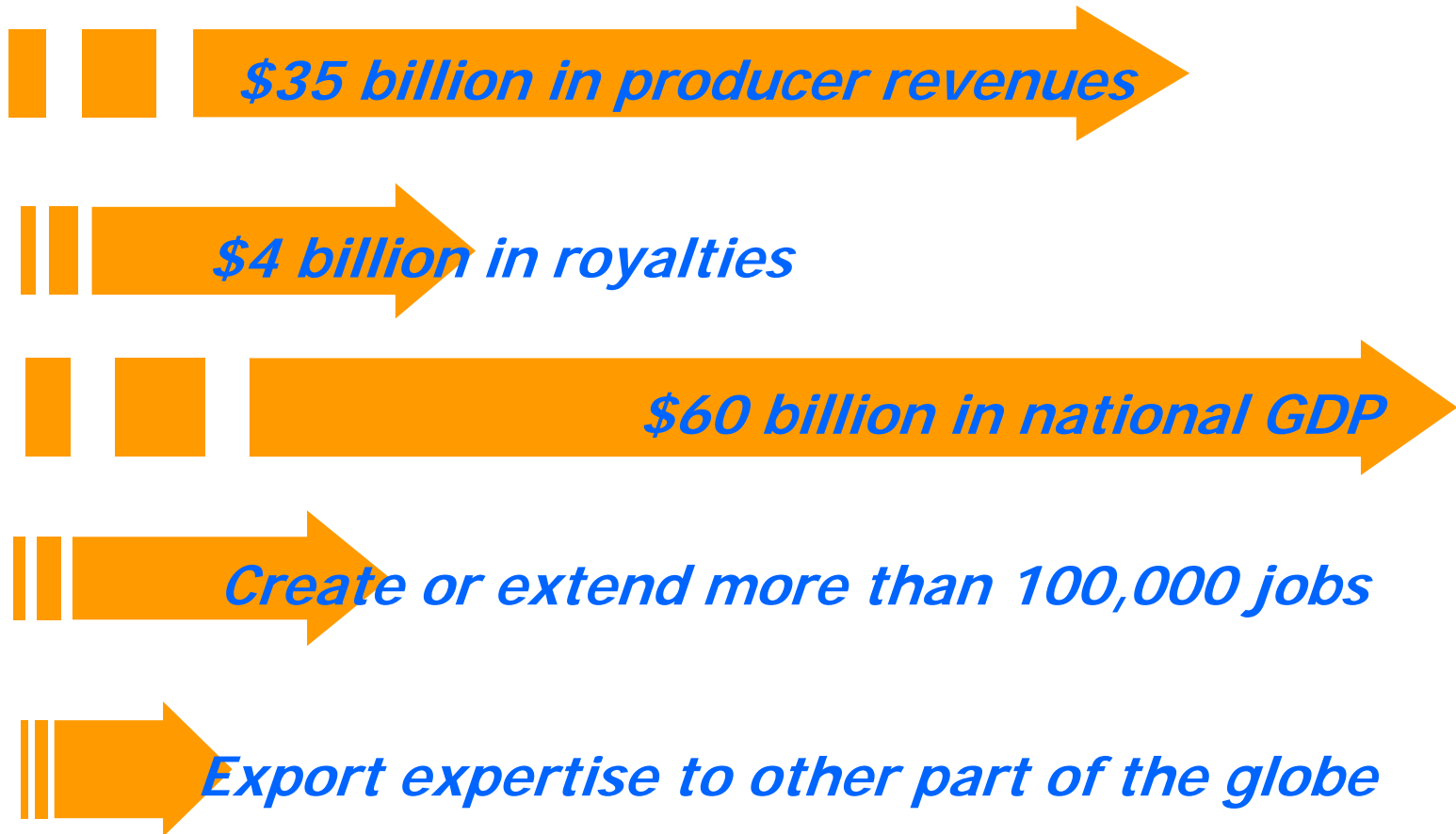
- Prices appear to be firm and sustainable
- New focus on EOR as an emerging growth platform for WCSB
 - ❑ Lots of residual oil
 - ❑ Existing infrastructure
 - ❑ No exploration risk
- Concerns about bitumen/HO:
 - ❖ Natural gas fuel costs
 - ❖ CO₂ emission costs
 - ❖ Diluent need
 - ❖ Water management costs
- Innovative Energy Technology Program (IETP) creates climate and provides incentives to test new technology
- APEC Study on reserves growth identifying new opportunities
 - ❖ Squeezing additional 5 B bbls & 25 TCF

Only a fraction of the oil-in-place has been produced



Source: Spudding Innovation Report, 2003

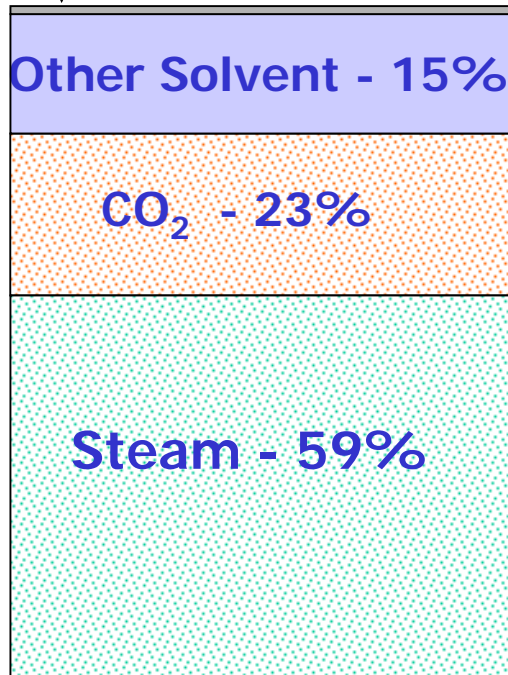
Economic impact of even 1% OOIP conventional oil recovery



EOR Production in the USA

In Situ Combustion – 0.5%

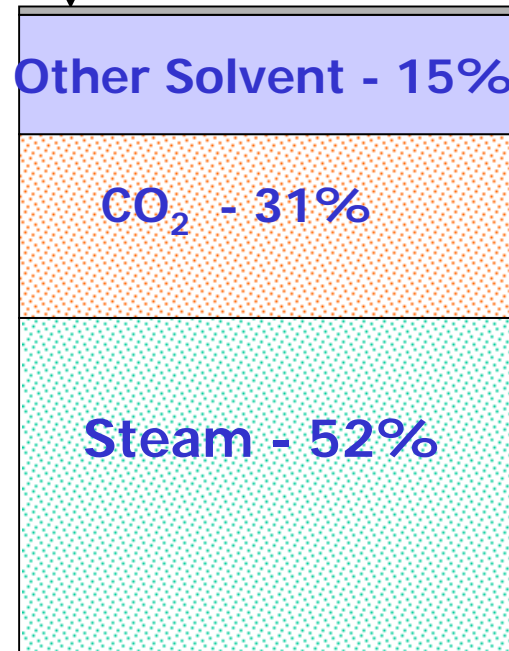
Chemical – 0.3%



1994 - 709,094 B/D

In Situ Combustion – 0.3%

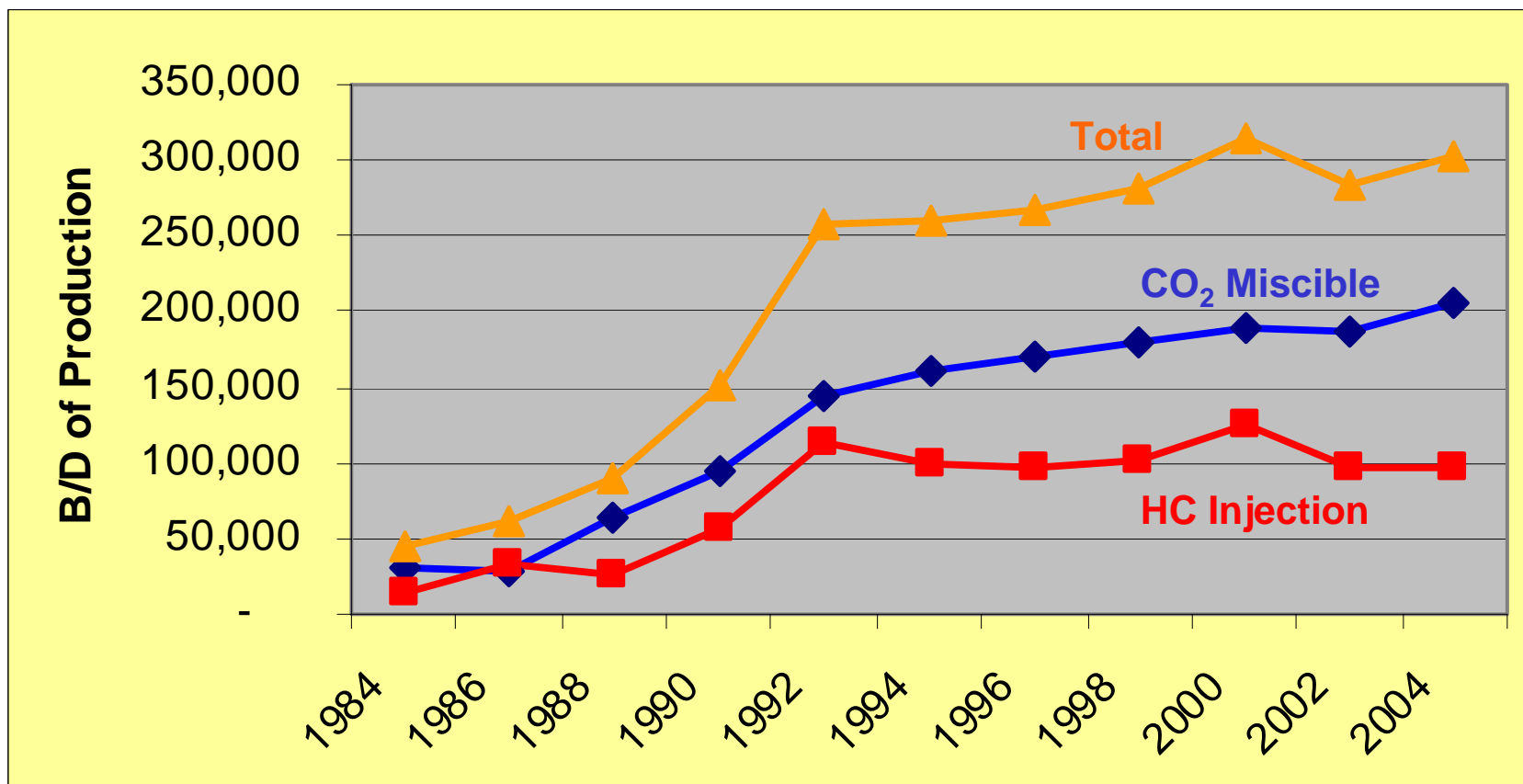
Chemical - 0%



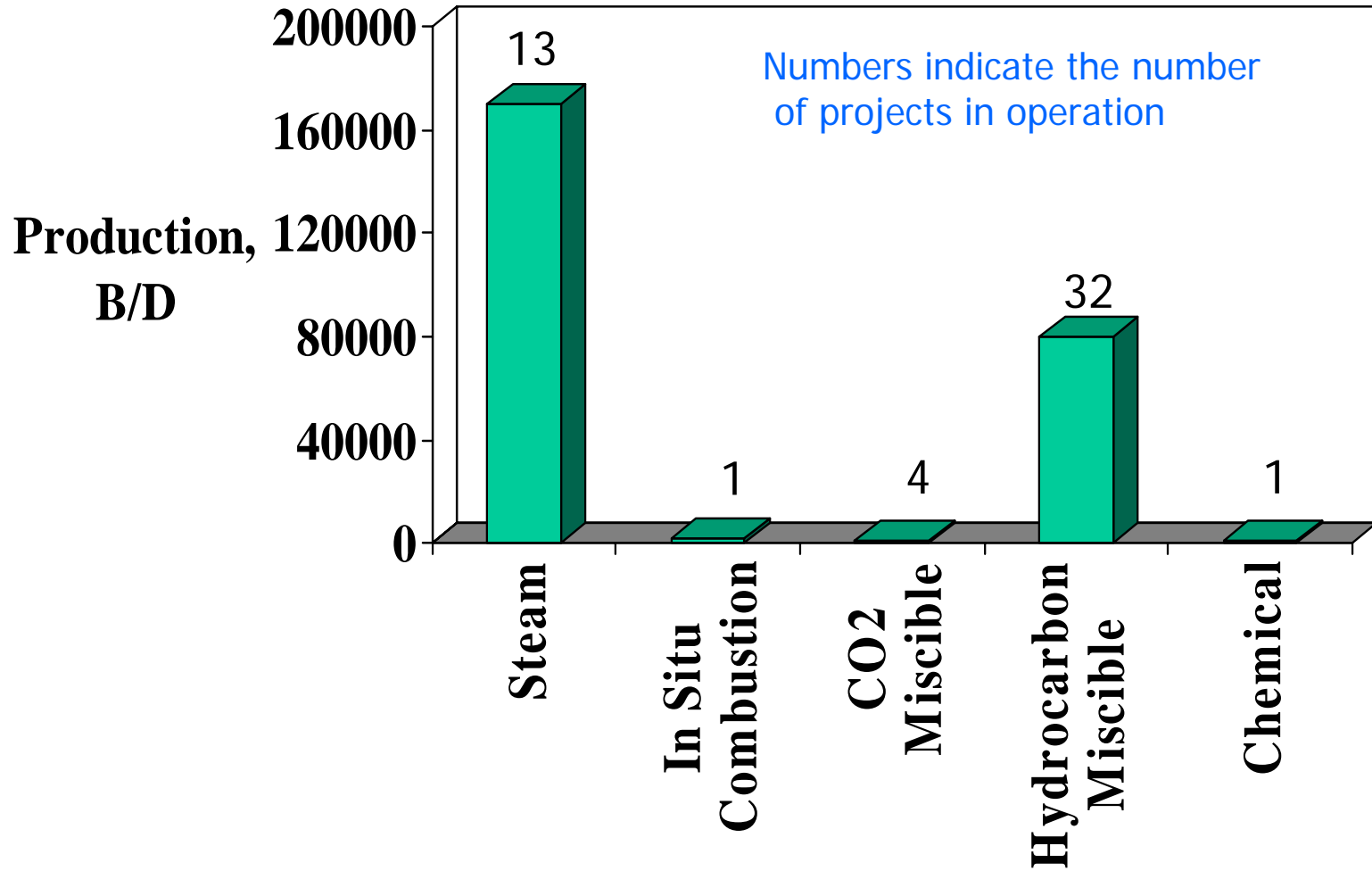
2004 - 663,461 B/D

Moritis, Oil and Gas Journal, April 20, 2004

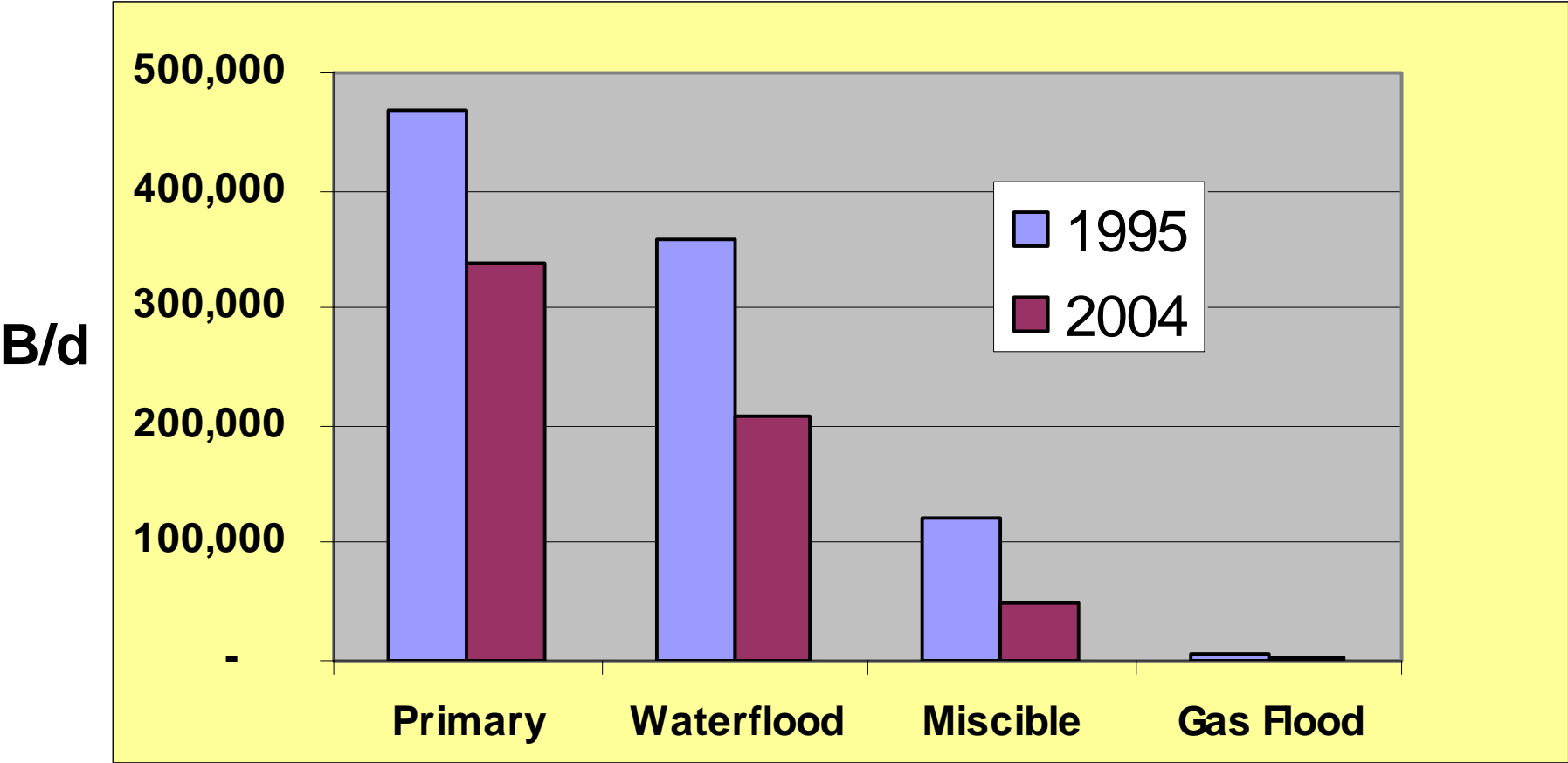
Evolution of US EOR Production (CO₂ and HC Injection)



EOR Production in Canada



Alberta Crude Oil Production by Recovery Method



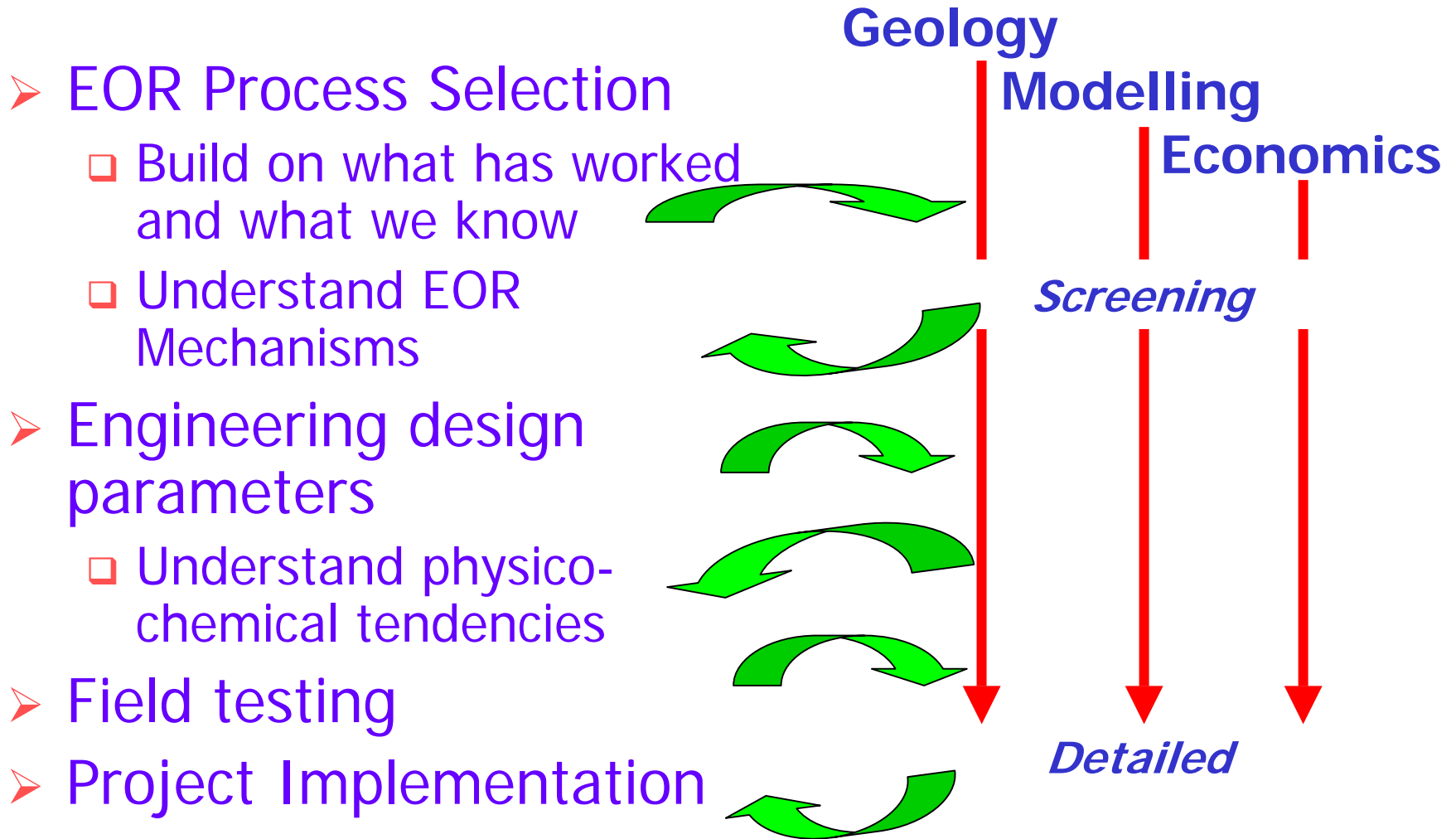
EUB Data



Additions of Reserves – Primarily Due to Technological Innovation Not so much EOR

- Horizontal and multi-lateral well production
- 3D seismic, time-lapsed seismic (4D) and visualization
- Coiled tubing for well workovers & completions
- Management of water
- Artificial lift
- Stimulation & treatment of wells
- Intelligent or smart completions
- Multiphase flow, pumping & measurement
- New logging tools
- Simulation, automation & communications

So where do we go from here?



EOR Technologies – What About Chemical Methods?

- Chemical methods: widely tested but little success
 - ❑ Surfactants & alkaline floods: loss of chemicals
 - ❑ polymer floods: improves sweep, largely uneconomic
 - ❑ Micellar flooding :small well spacings, largely uneconomic
 - ❑ ASP (Alkaline-Surfactant-Polymer): promising field trials, could become economic at high oil prices

Major Challenge for Chemical EOR

- Economic life of waterflood leaves 2/3 of oil behind
 - ❑ few continuous pathways for oil to flow
 - ❖ poor reservoir sweep efficiency
 - ❖ microscopic displacement efficiency
 - ❖ process performance efficiency



(Larson et al. 1982)

EOR Technologies Needing a Major Push in WCSB

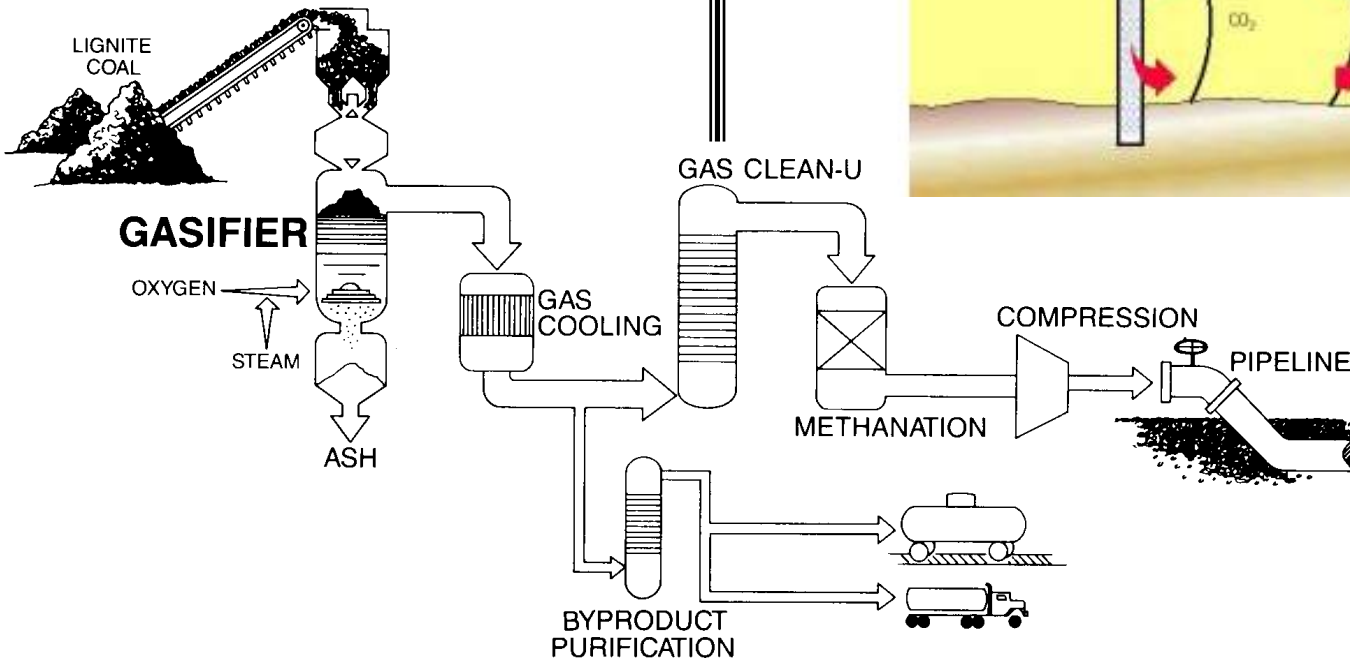
- Miscible CO₂: Requires CO₂ price < \$2/Mscf
 - ▣ Future price of CO₂ based on willingness to pay to restrain GHG emissions
- Solvent Miscible displacement – great potential when solvent readily available.

Carbon Dioxide Miscible Flood – Learnings from Joffre

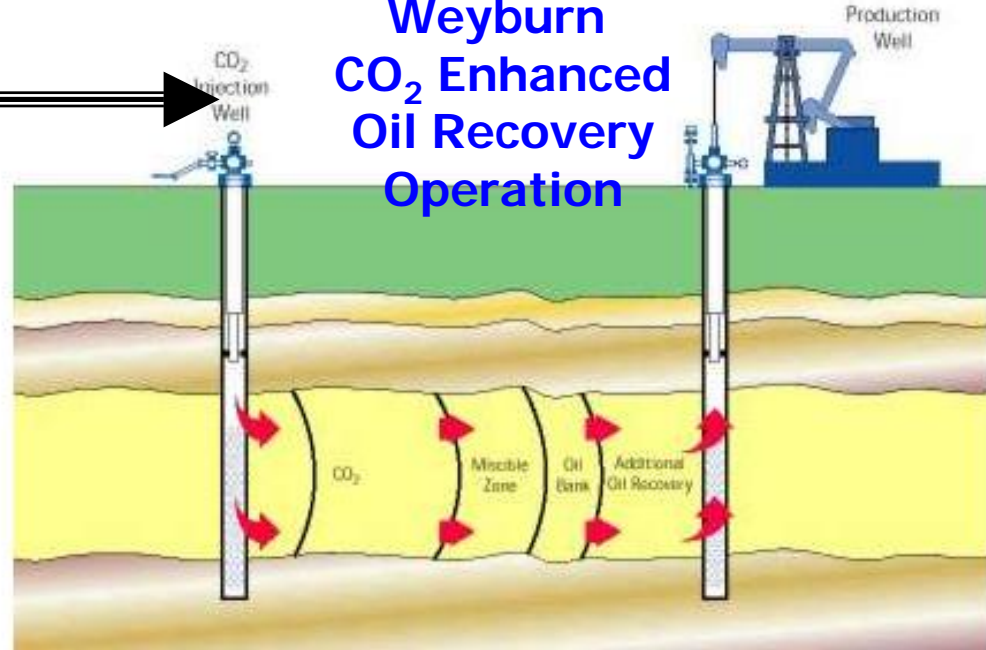
- CO₂ Flooding Project (1983 – 2005)
- EOR of OOIP: 12% (produced); 25% (projected) from 15 patterns.
- Simultaneous CO₂ - water injection
 - ▣ Ratio 0.8:1 → 1:1 (water:oil)
- Current oil rate: 100 m³/d for 250 x 10³ Sm³/d of CO₂
 - ▣ CO₂ injected now contains 20% recycled HC's
- CO₂ Utilization
 - 1m³ of oil produced – 1929 Sm³ CO₂ injected (10.8 Mcf/bbl) – GROSS
 - 720 Sm³ CO₂ injected (4.0 Mcf/bbl) - NET

Coal Gasification produces Substitute Natural Gas and CO₂ for Enhanced Oil Recovery

North Dakota Coal Gasification Plant

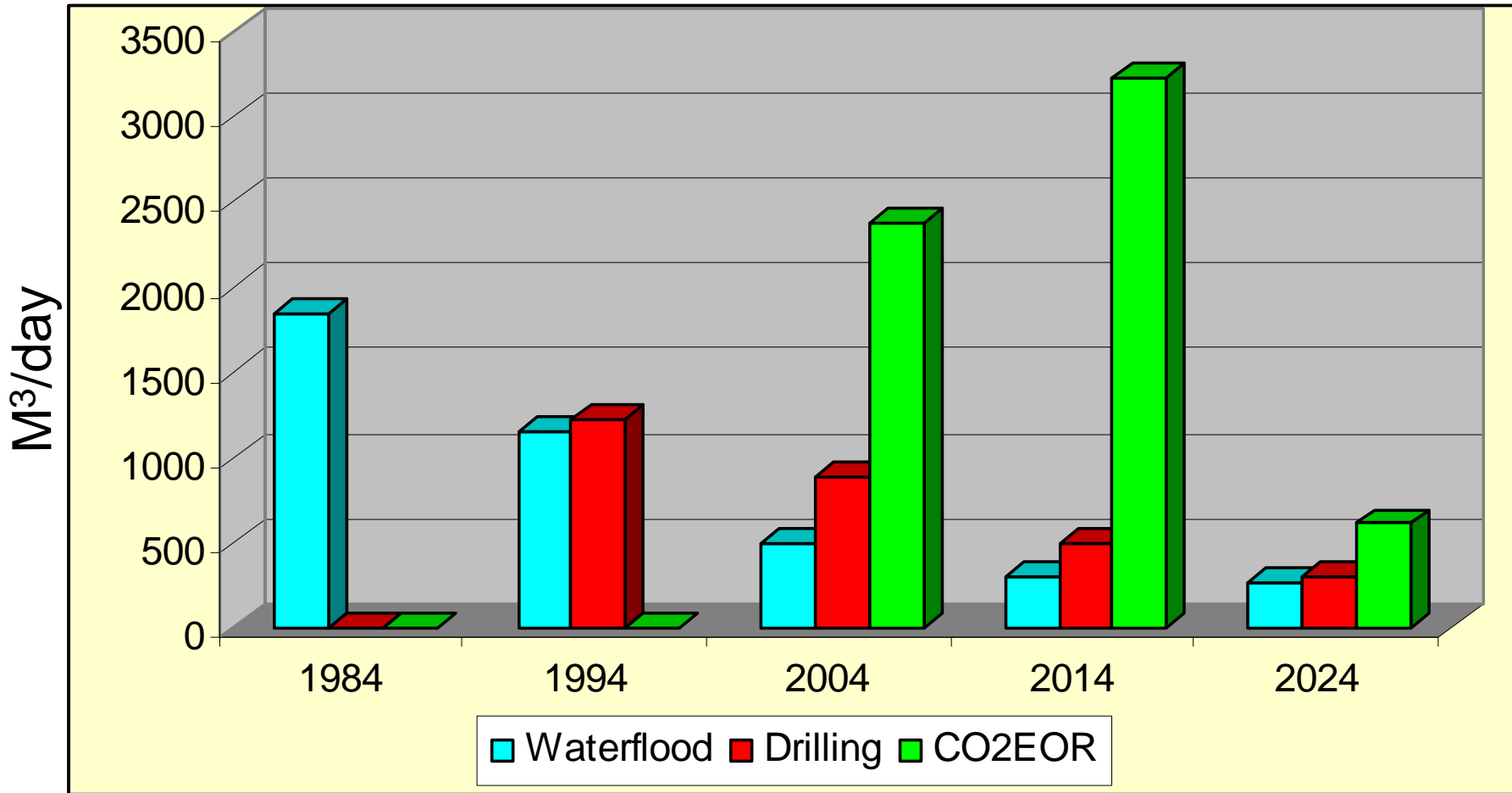


Weyburn CO₂ Enhanced Oil Recovery Operation



Substitute Natural Gas

What if we could do more Weyburns?



Suggested Focus for Research and Technology

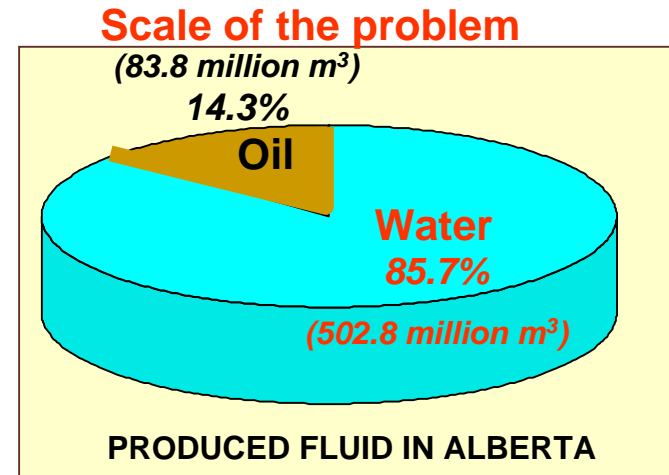
Get good at what works

- CO₂ EOR
 - WAG & variations
- Solvent processes
 - Miscible Immiscible
 - Pressure maintenance
 - Gas injection, flue gas

Adapt HO Experience

- VAPEX
- Thermal
 - Steam distillation drive
 - Combustion
 - Pressure maintenance

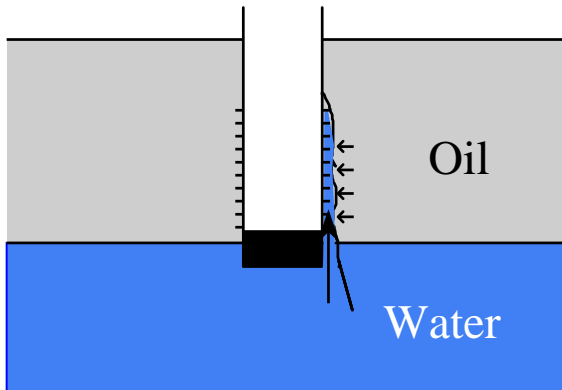
Advance Water Management



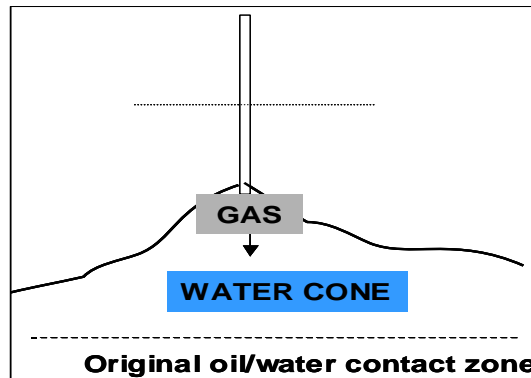
- Conformance Control
- Water Shut-off
- Mobility control
- Toe-to-heel waterflooding
- Less fresh water use

Enhanced Water Management

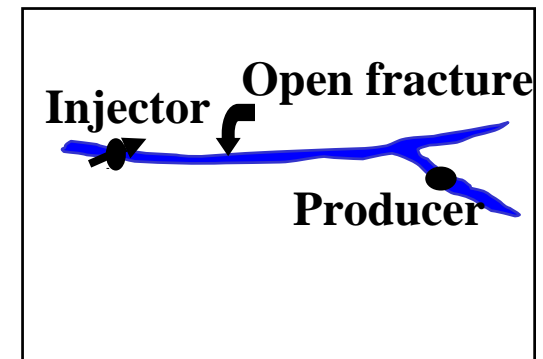
- Mechanical methods
- Gels
 - ❑ Chemical gels
 - ❑ Clay gels
- AWACT (anti-water coning technology)



➤ Fractures behind casing



➤ Water coning



➤ Fracture by-pass