PTAC PETROLEUM TECHNOLOGY ALLIANCE CANADA

30th Annual CNS Conference

Energy for Oil Sands Production

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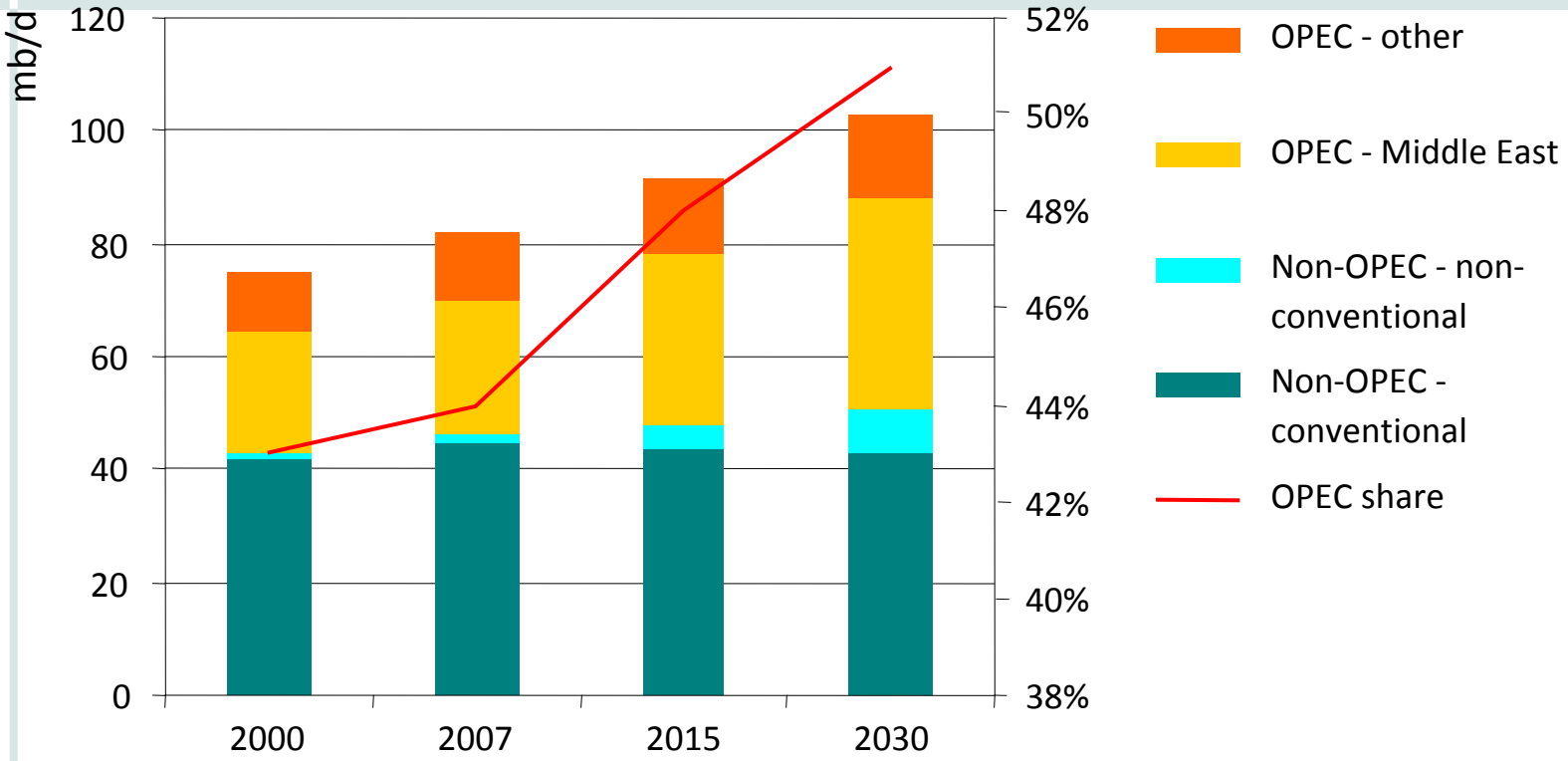
What is happening?

- In the long term the energy demand will increase due to the world population increase and expected economic growth
- Supply of easy oil can not keep up with the increase in demand
- Oil will stay as the main source of the transportation fuel in the foreseeable future
- Globally production of heavy crude is increasing
- More energy production means more CO2 emitted at a time when climate change looms as a critical global issue
- Obama's energy policy will have a profound impact on oil sands development

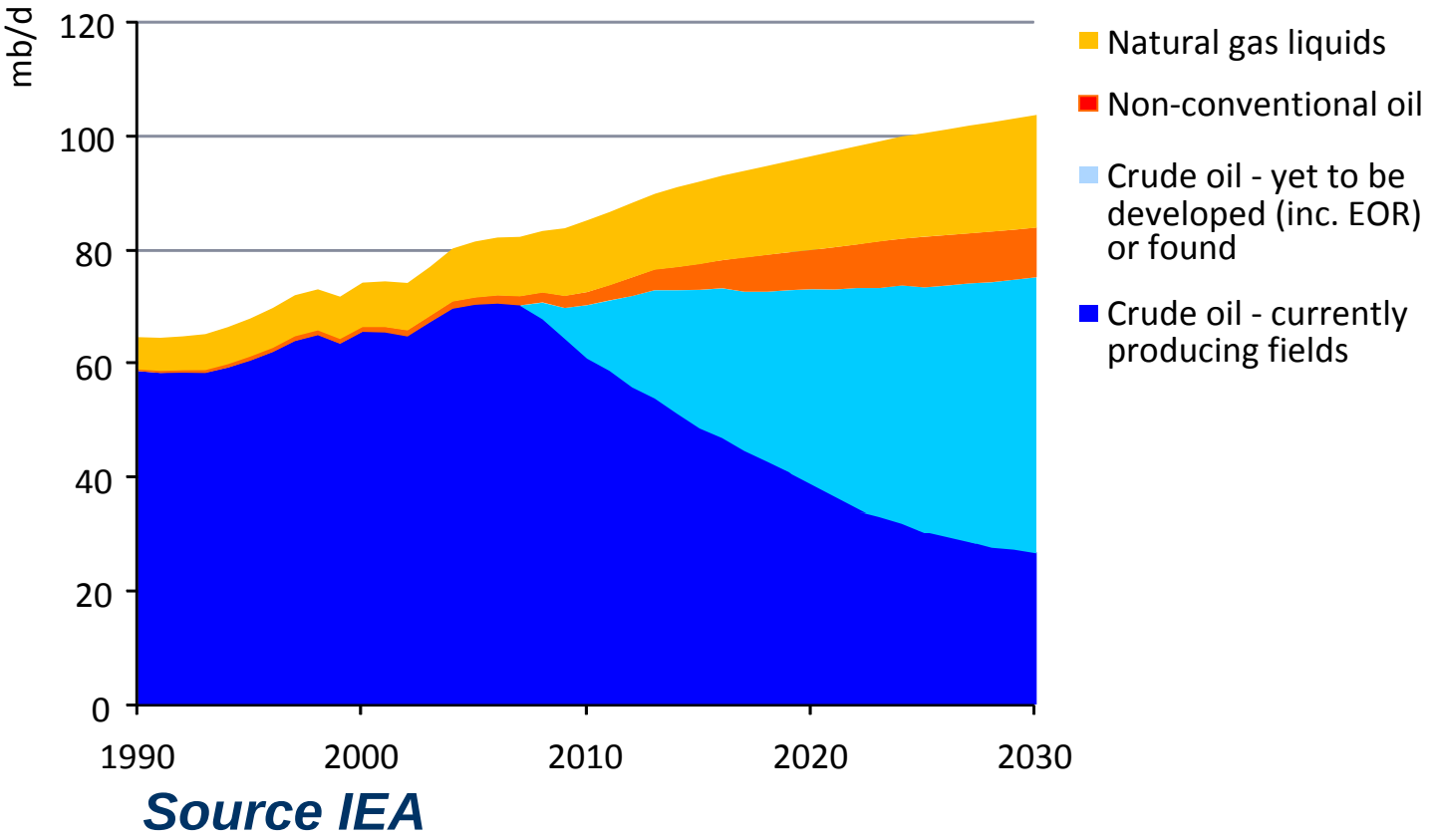
World oil production by OPEC/non-OPEC



Source IEA

Production rises to 104 mb/d in 2030, with Middle East OPEC taking the lion's share of oil market growth as conventional non-OPEC production declines

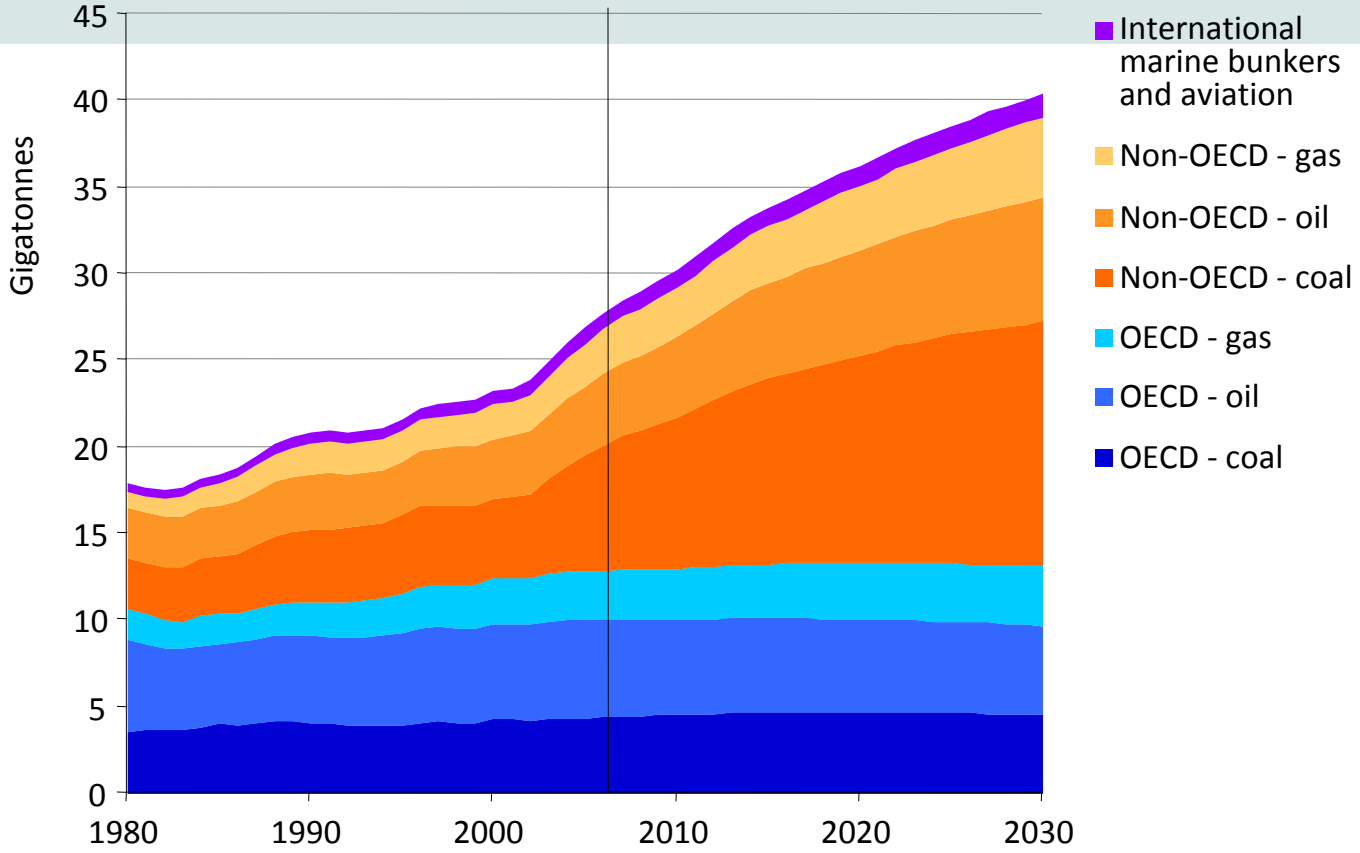
World oil production by source in the Reference Scenario



Source IEA

64 mb/d of gross capacity needs to be installed between now and 2030 to meet demand growth & offset decline

Energy-related CO_2 emissions



Source IEA

97% of the projected increase in emissions between now & 2030 comes from non-OECD countries – three-quarters from China, India & the Middle East alone

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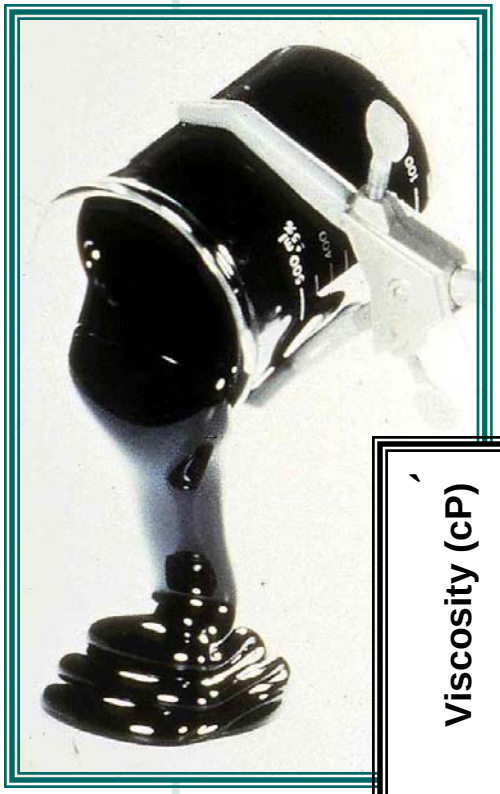
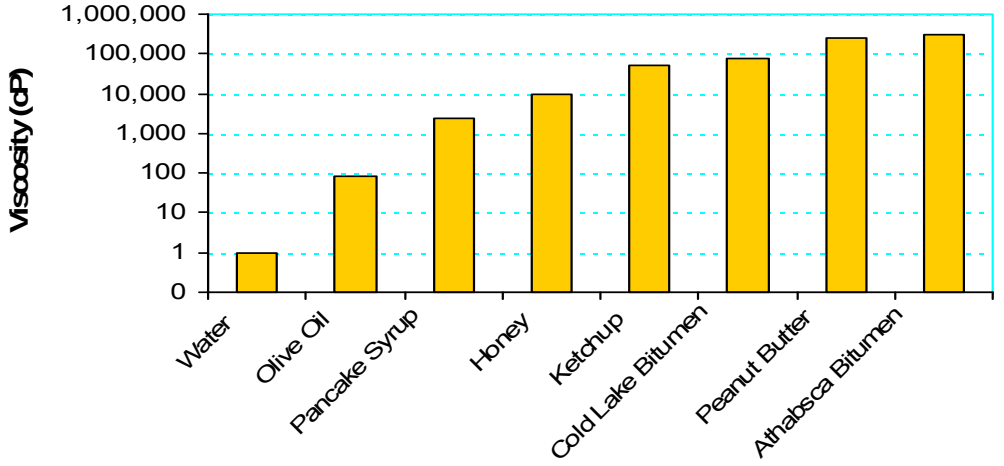
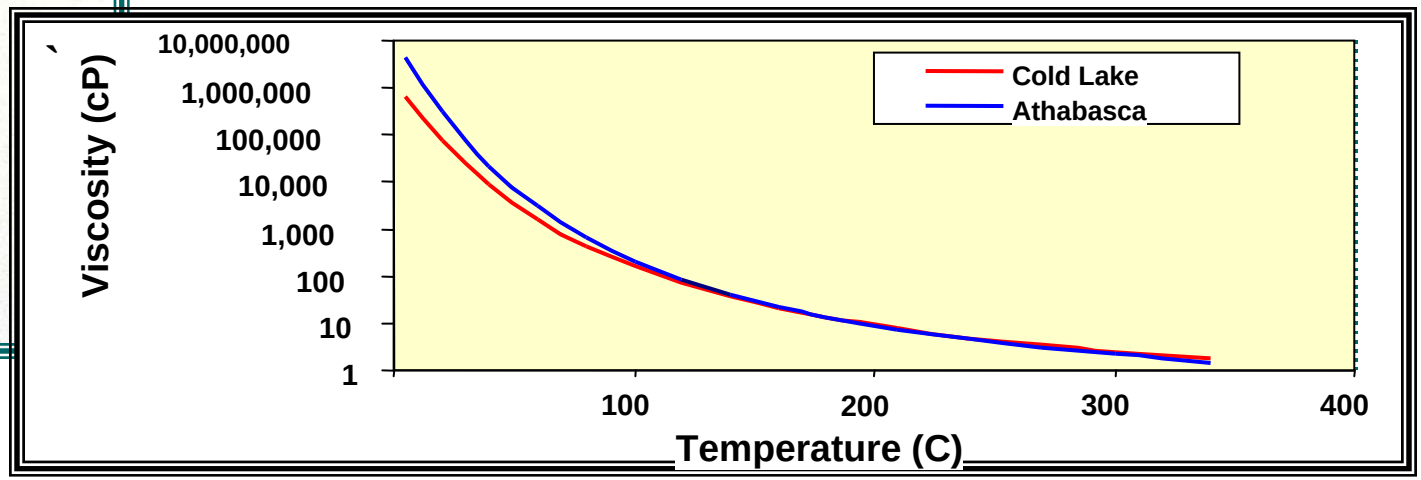
Oil Sands 101

The Bitumen Recovery Challenge







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The Resources

The Largest Oil Resources in The World

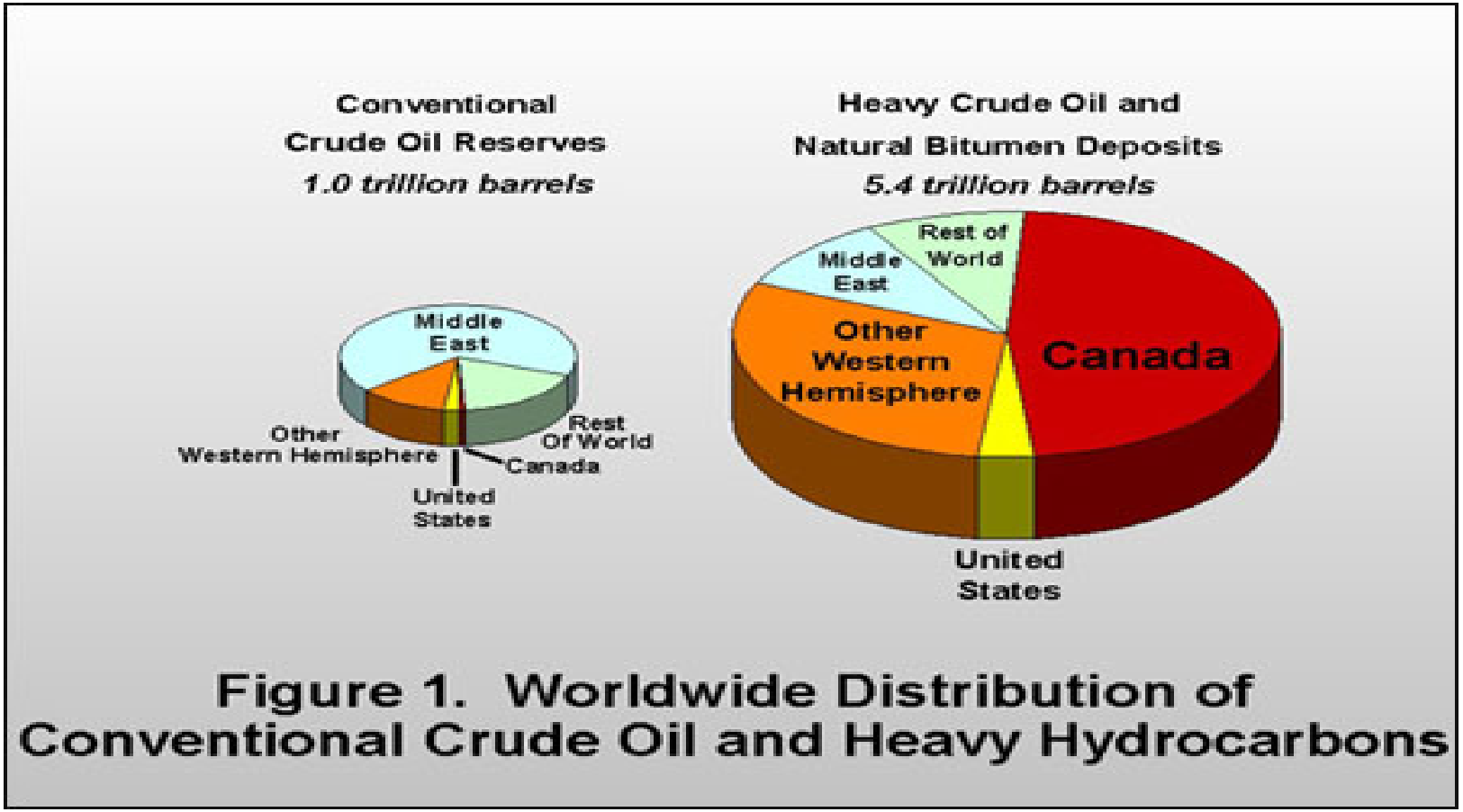

Figure 1. Worldwide Distribution of Conventional Crude Oil and Heavy Hydrocarbons

Petroleum Equities Inc., Potomac-Severn Group LLC, December 2004

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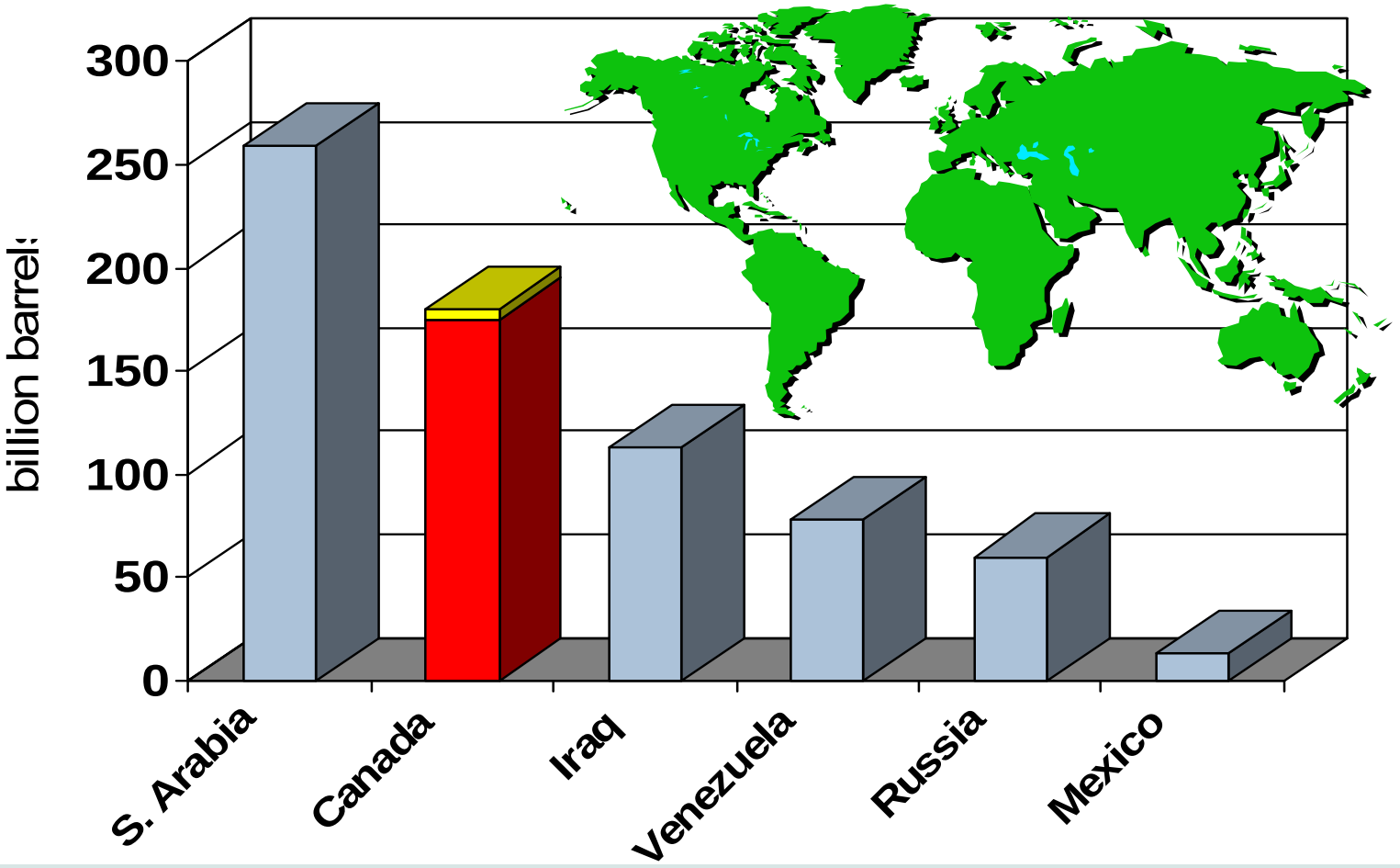
Proven World Crude Oil Reserves



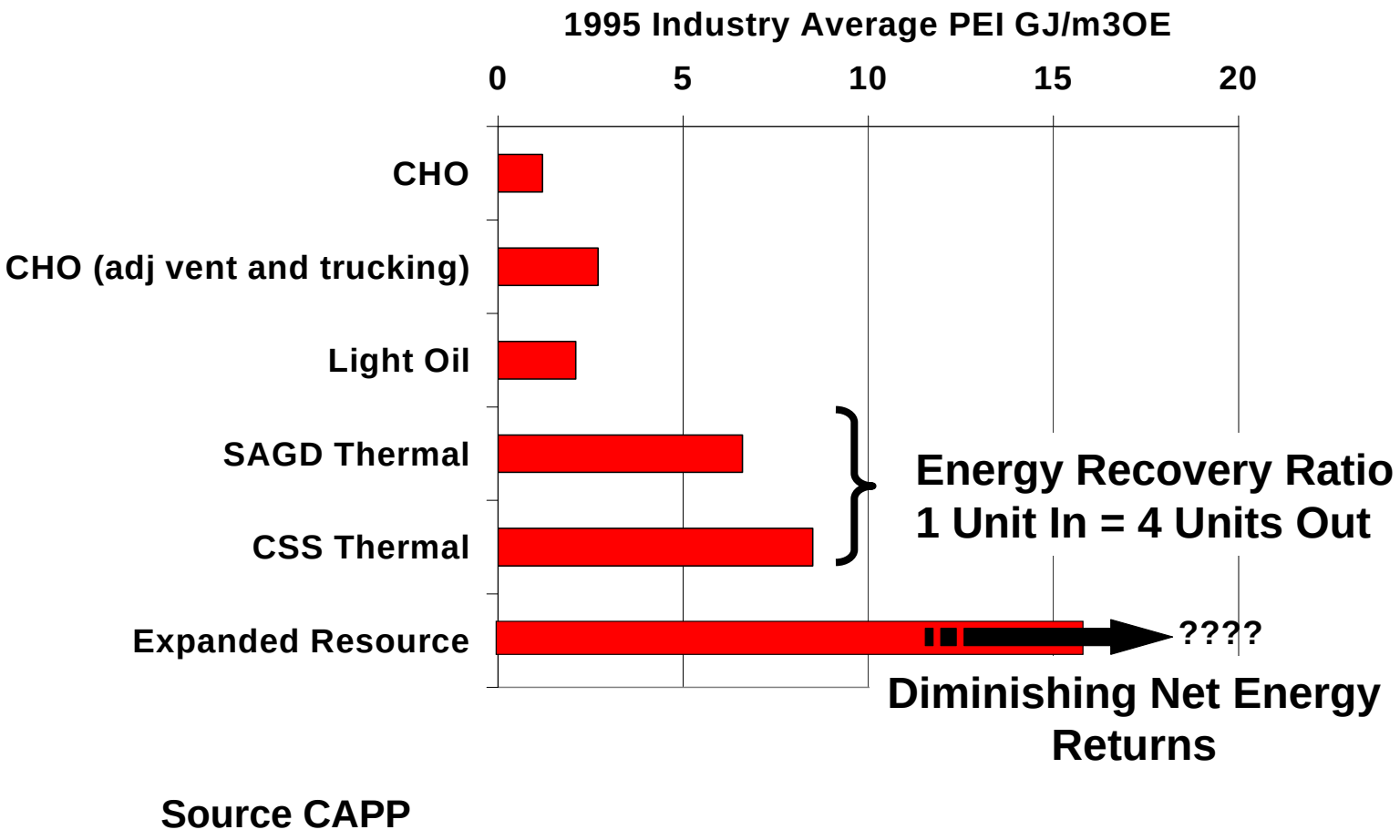
Sources: Oil and Gas Journal – Dec 2002, AEUB

Cumulative Increase in GDP in $ Billions (2000-2020)*

Alberta	1,167
Other Provinces	310
Outside Canada	268

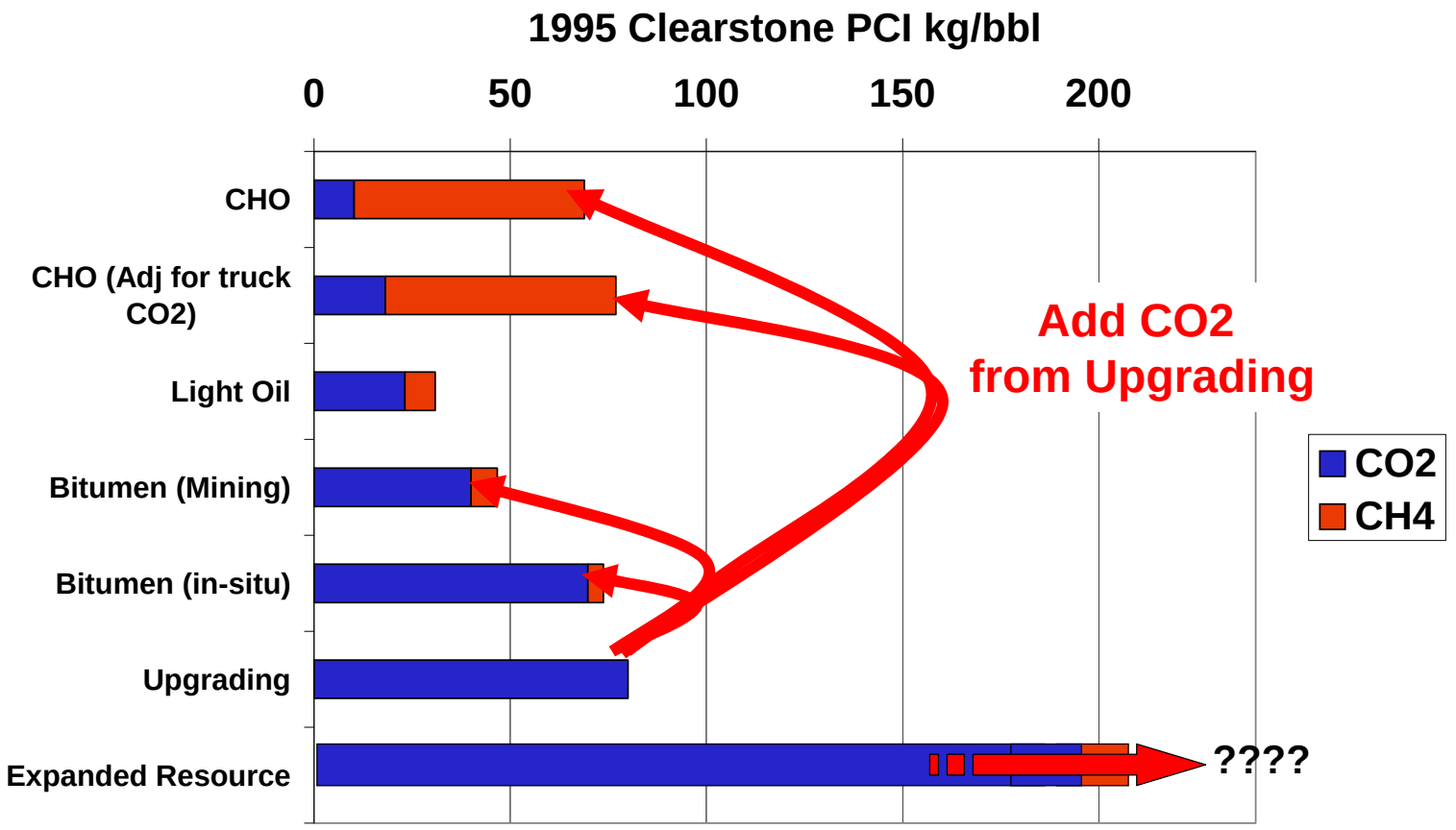
*Canadian Energy Research Institute, *Economic Impact of Alberta's Oil resources*, August 2006

Energy Intensities



Source CAPP

GHG Intensities



PTAC's Technology Options to Reduce GHG Emissions from Oil Sands

- **CO2 sequestration**
- **Eco efficiency Program**
- **Emerging exploitation technologies (FGSS, etc.)**
- **Alternative solutions to replace natural gas consumption**

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Use of Natural Gas:
Is it a poor use of a clean fuel?
Do we have enough gas?

Alternative Solutions to Replace Natural Gas

- Gasification of coal, coke or asphaltenes, etc. combined with CO2 sequestration
- Burning bitumen combined with CO2 sequestration
- Nuclear
- Other options

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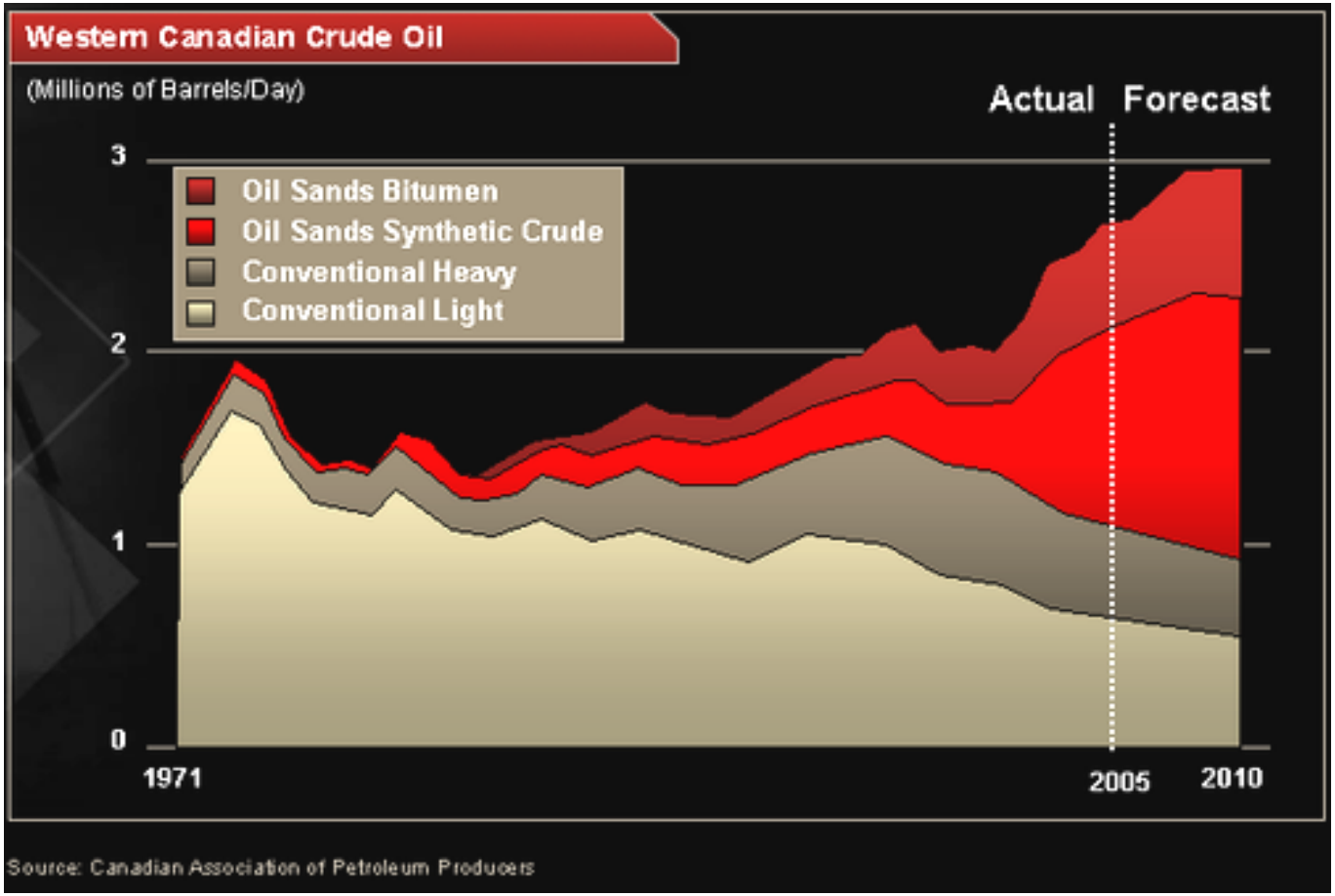
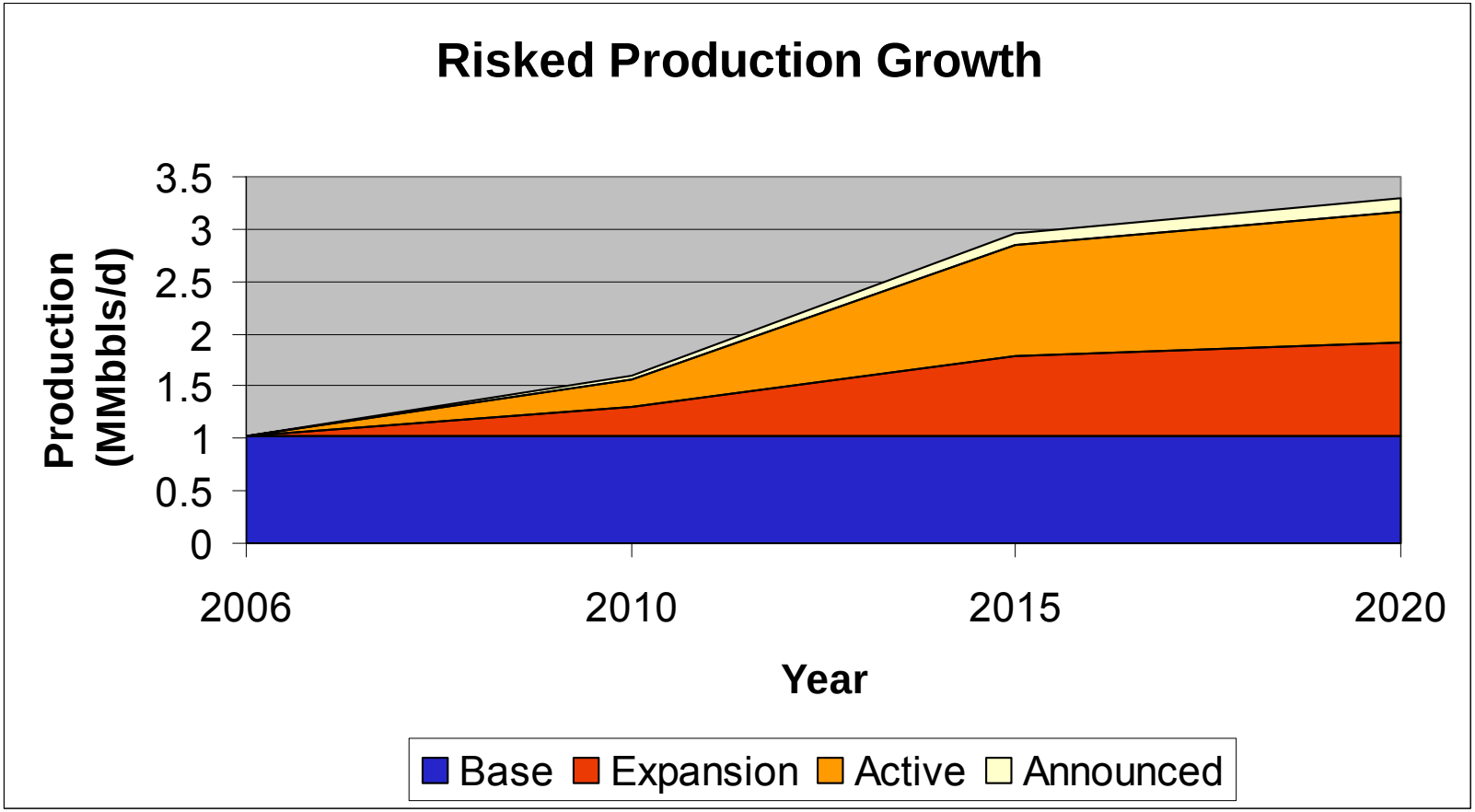
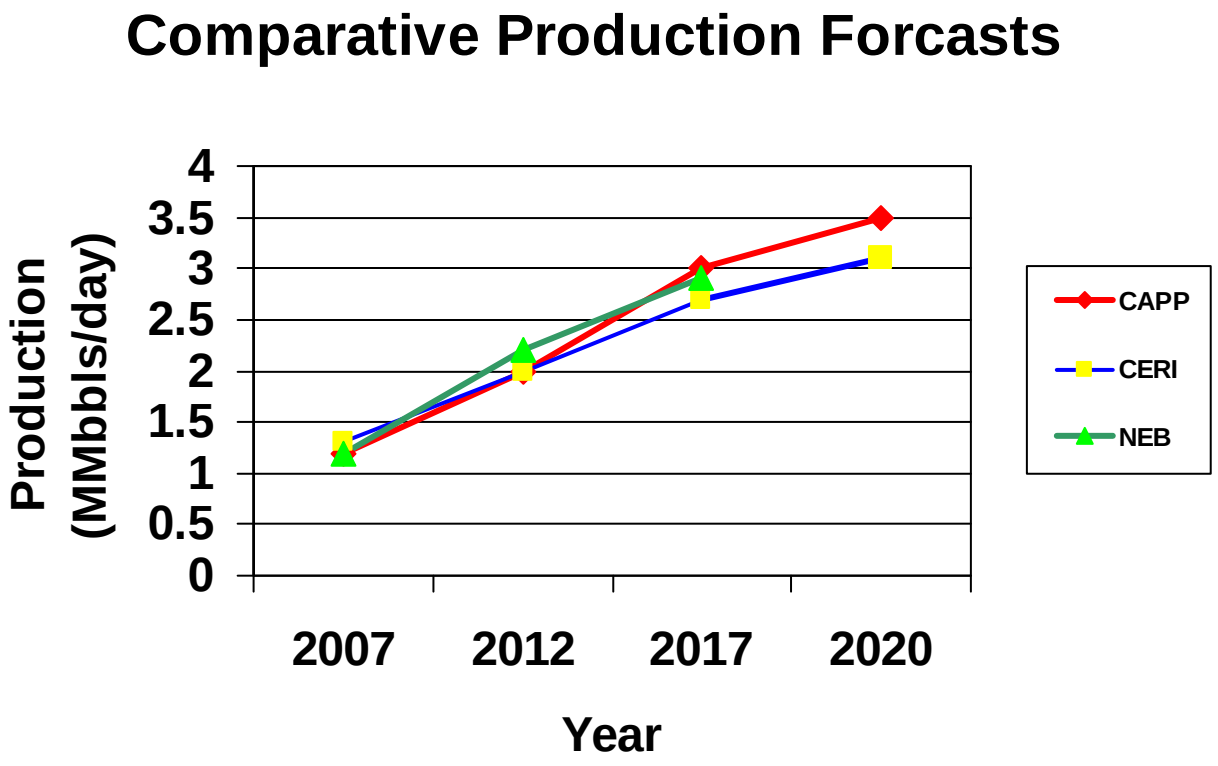
Gas Consumption Forecast



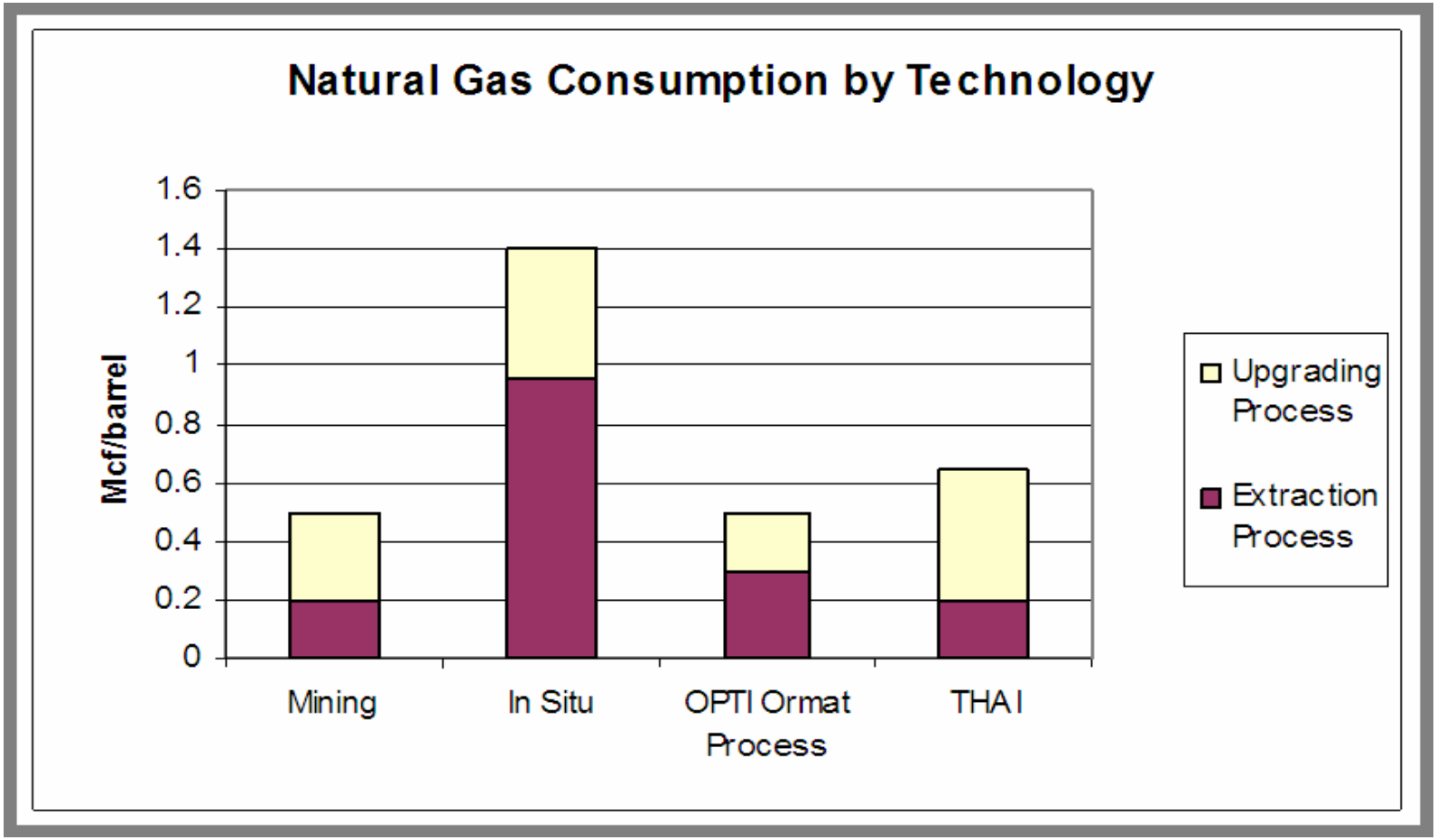
Oil Sands Production Forecasts
Forecast Risked Growth



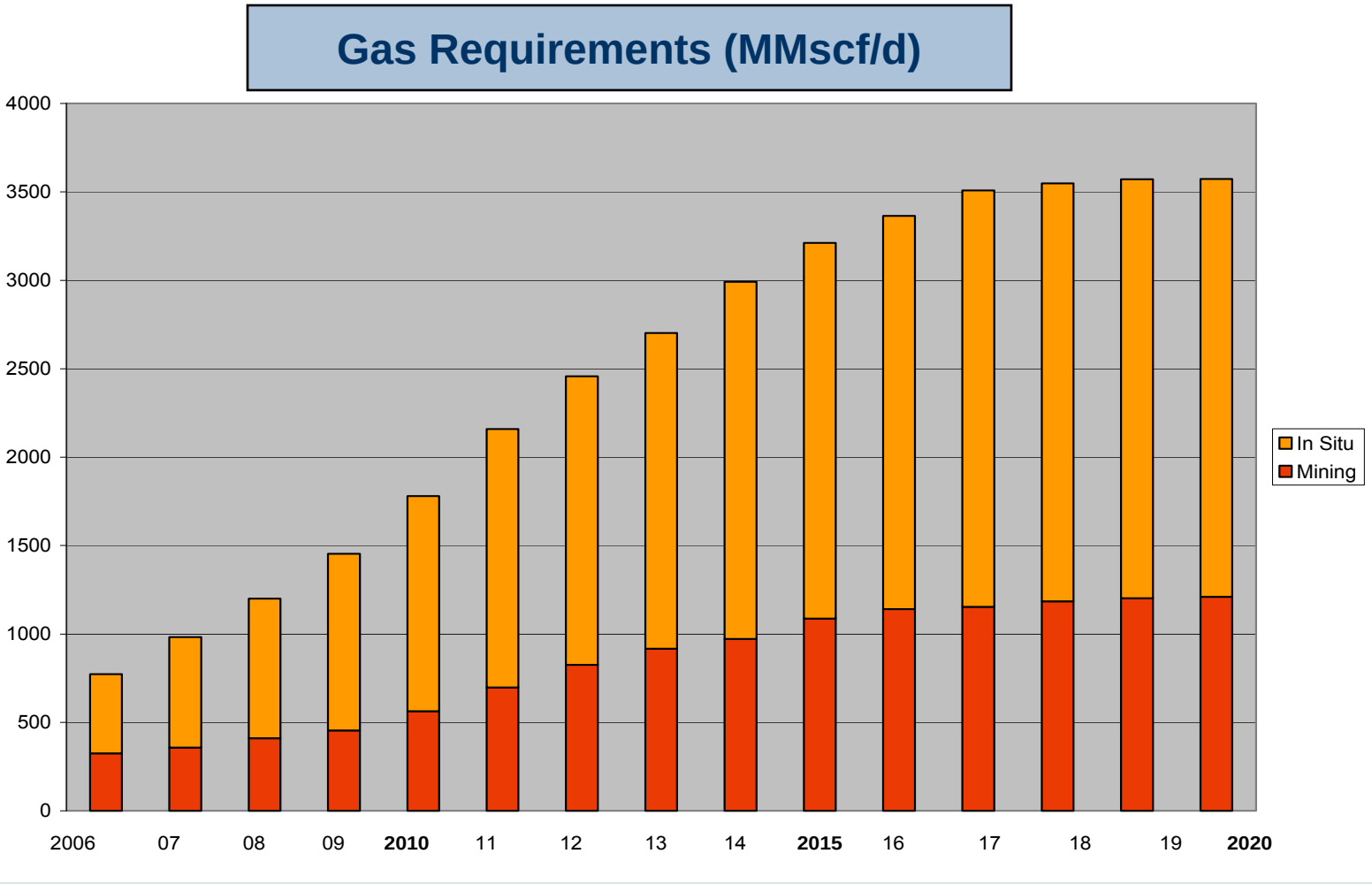
Oil Sands Production Forecasts



Natural Gas Consumption

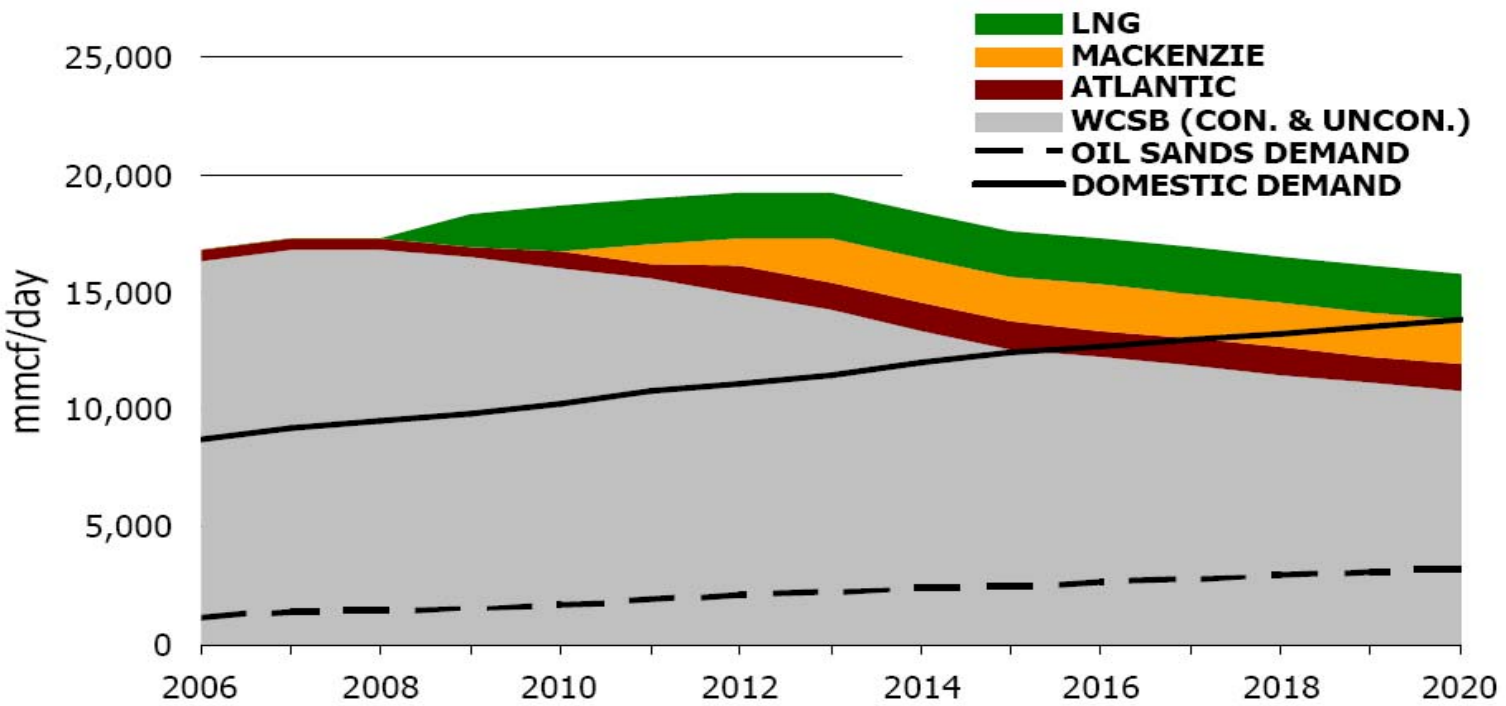


Gas Requirements

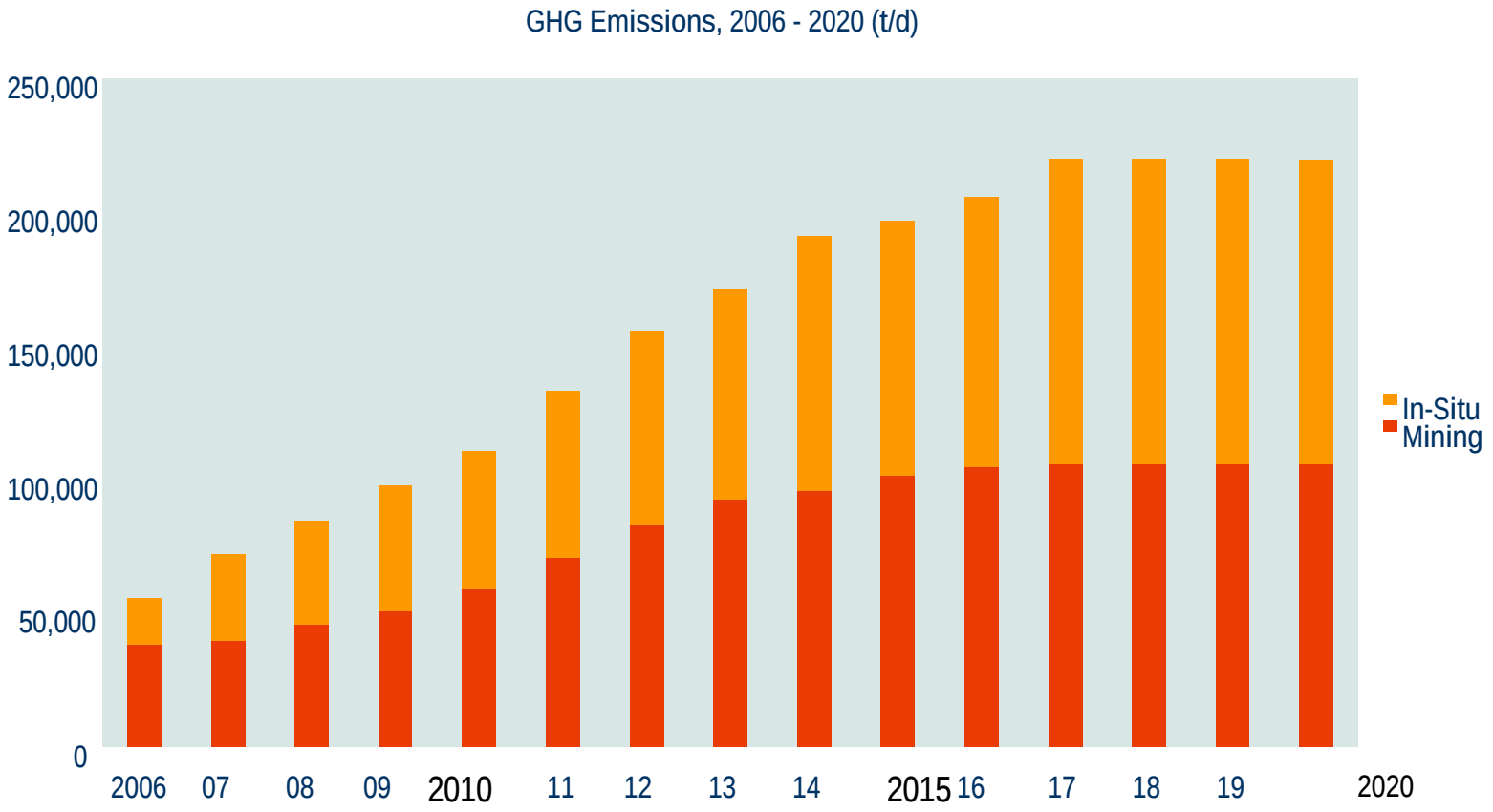


Gas Supply and Demand

Projected Canadian Natural Gas Supply/Demand Balance



GHG Emissions



Application of Nuclear Technology – Opportunities

- Low operating cost
- Reliable
- Emission-free energy
- Flexibility in generating steam, hydrogen, heat, and electricity
- Reduction in consumption of natural gas
- Energy cost certainty
- Reduces premium fuel availability concerns
- High tech jobs

Application of Nuclear Technology – Challenges/Considerations

- High capital cost
- Technical feasibility and economic viability
- Distance to transport steam economically
- Size dictates next generation reactors
- Construction challenges: remote site with difficult access
- Harsh weather conditions
- Labor/skills shortages
- Lack of experience with nuclear technology or nuclear power generation
- Lack of regulatory frame work
- Safety
- Security
- Commercial application is likely post 2025

Application of Nuclear Technologies

- **Phase 1: Evaluate nuclear technologies for oil sands application**
- **Phase 2: Study of application of high temperature gas reactors to in-situ operations**
- **Phase 3: Detailed Engineering study**
- **Phase 4: Implementation of field pilot tests**

Phase one: Evaluated Options

- 120,000 BPD In-situ (SAGD), constructed in four (4) 30k BPD stages;
-
- 100,000 BPD Mining; and
- 100,000 BPD Integrated Mine and Upgrader.

Mining and In-Situ

- Bitumen production
- Project life
- Steam oil ratio
- Pressure at well head
- Steam quality
- Electricity requirement
- Mining and in-situ/Integrated

Study Results

- NPPs with water cooled reactors have thermal capacities greatly exceeding the energy requirements of the evaluated options.
  - Water cooled reactor are not hot enough to generate steam for SAGD
- High Temperature Gas Reactors (HTGRs) could meet the technical requirements for the three (3) scenarios considered, but are not currently commercialized.
- Among the considered technologies are the Pebble Bed Modular Reactor (PBMR), Toshiba 4S, and the General Atomics High Temperature Gas Reactor (GA-HTGR).

Study results

- The introduction of nuclear energy into the Oil Sands region will be a lengthy and expensive process
- the timing is likely post 2025.
- The Project duration, including site selection, environmental assessment, licensing and construction could span over 15 years.
- A practical way of utilizing the existing commercial NPP designs for use in the Oil Sands region would be to adopt a ‘utility’ approach for the delivery of energy (in the form of steam and electricity) to multiple Oil Sands facilities, and for providing electricity to the Alberta power grid.

Conclusions

- Development of Canada's Oil Sands resources are essential to meet the global energy demand and stimulate Canada’ economic prosperity.
- Application of existing and emerging technologies can ensure sustainable development of Canada’s world class Oil Sands resources.

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Thank You