

Economic and Environmental Impacts of
Alternative Energy Sources for Canada's Oil
Sands Development: a Hybrid LCA Approach
INLCA/LCM 2006

October 5th, 2006

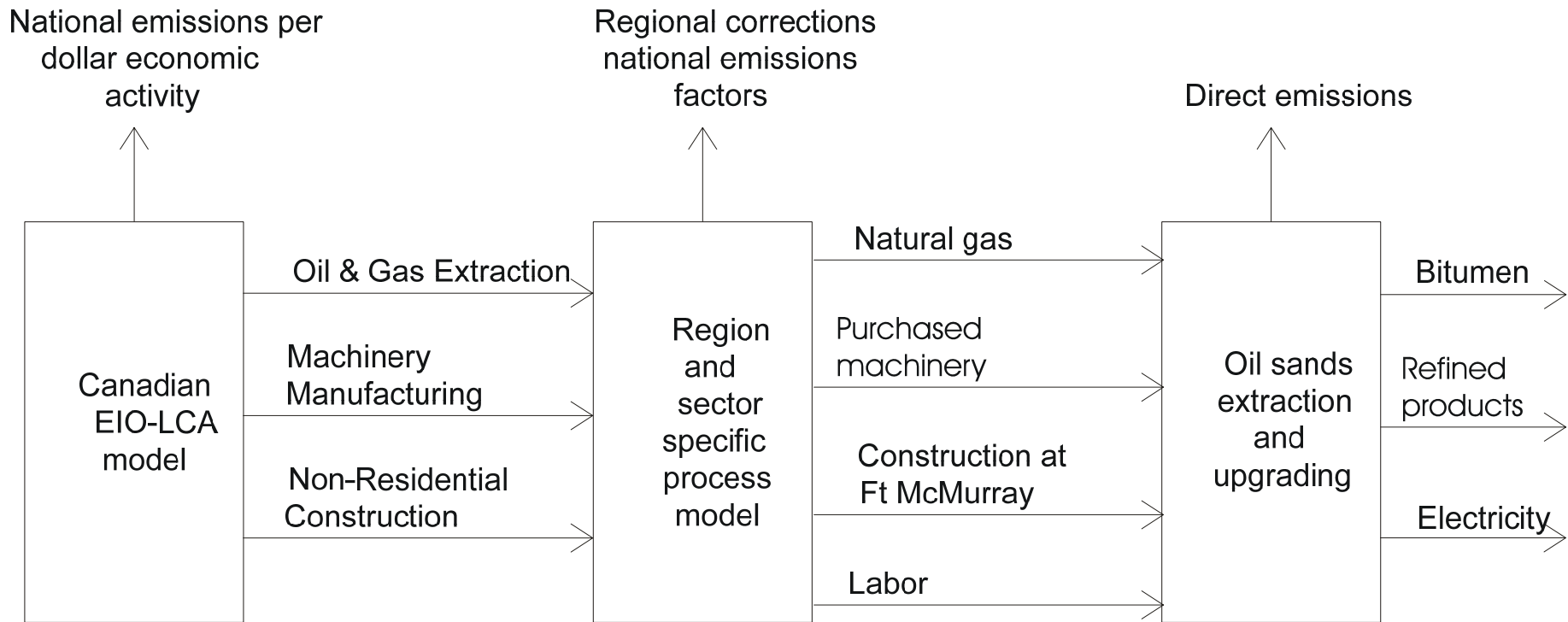
Joule Bergerson & David Keith



Introduction

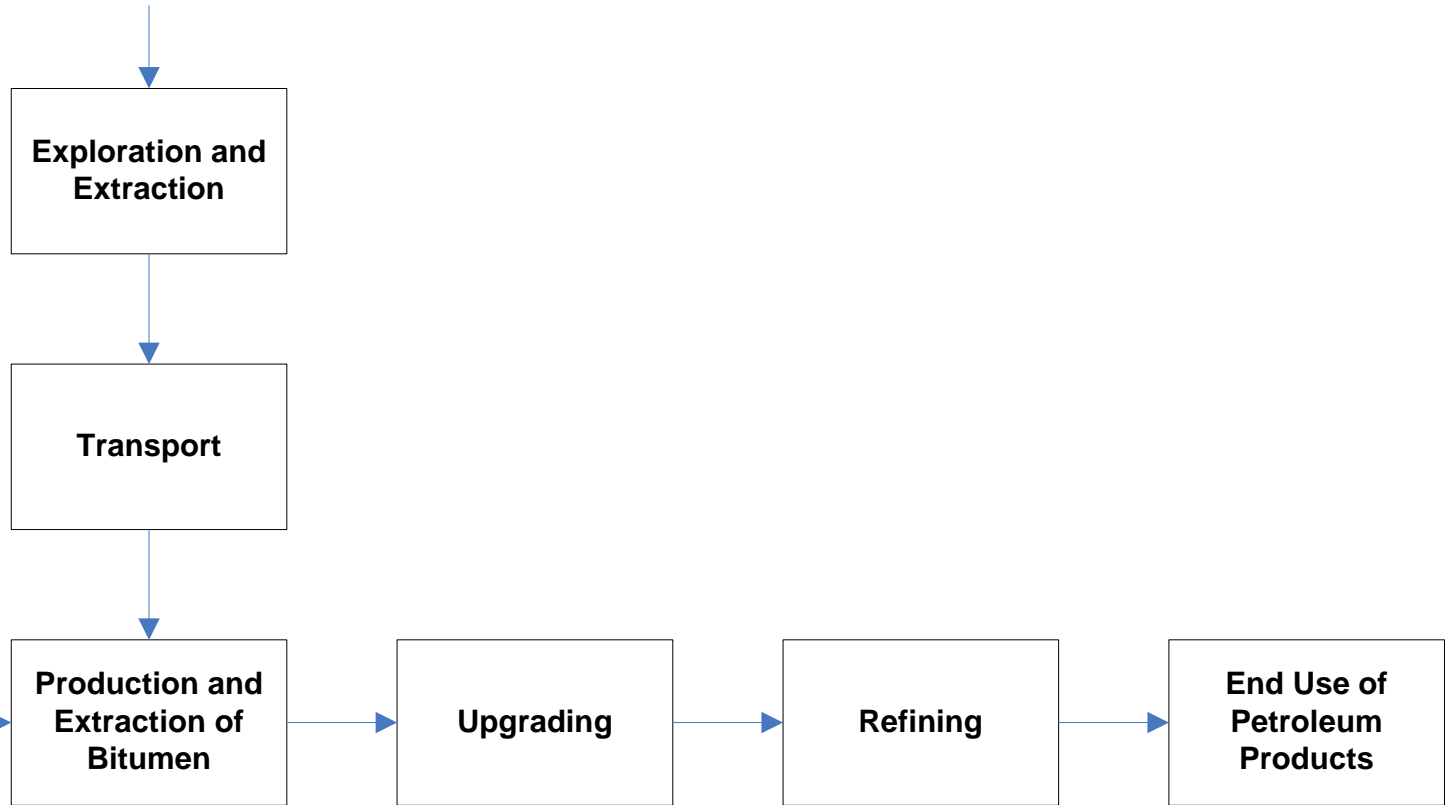
- The price and availability of natural gas in North America has forced energy intensive industries to reassess their fuel supply options. The extraction phase of oil sands operations consumes large quantities of natural gas.
- We apply the hybrid LCA model to investigate the implications of using coal to supply heat and electricity to oil sands operations as an alternative to natural gas.
- Coal is an inherently dirty fuel and rail systems are costly to build. However, the fuel itself is relatively cheap, abundant and nearby. Technologies exist today that minimize many of the environmental problems associated with this fuel.

Hybrid LCA

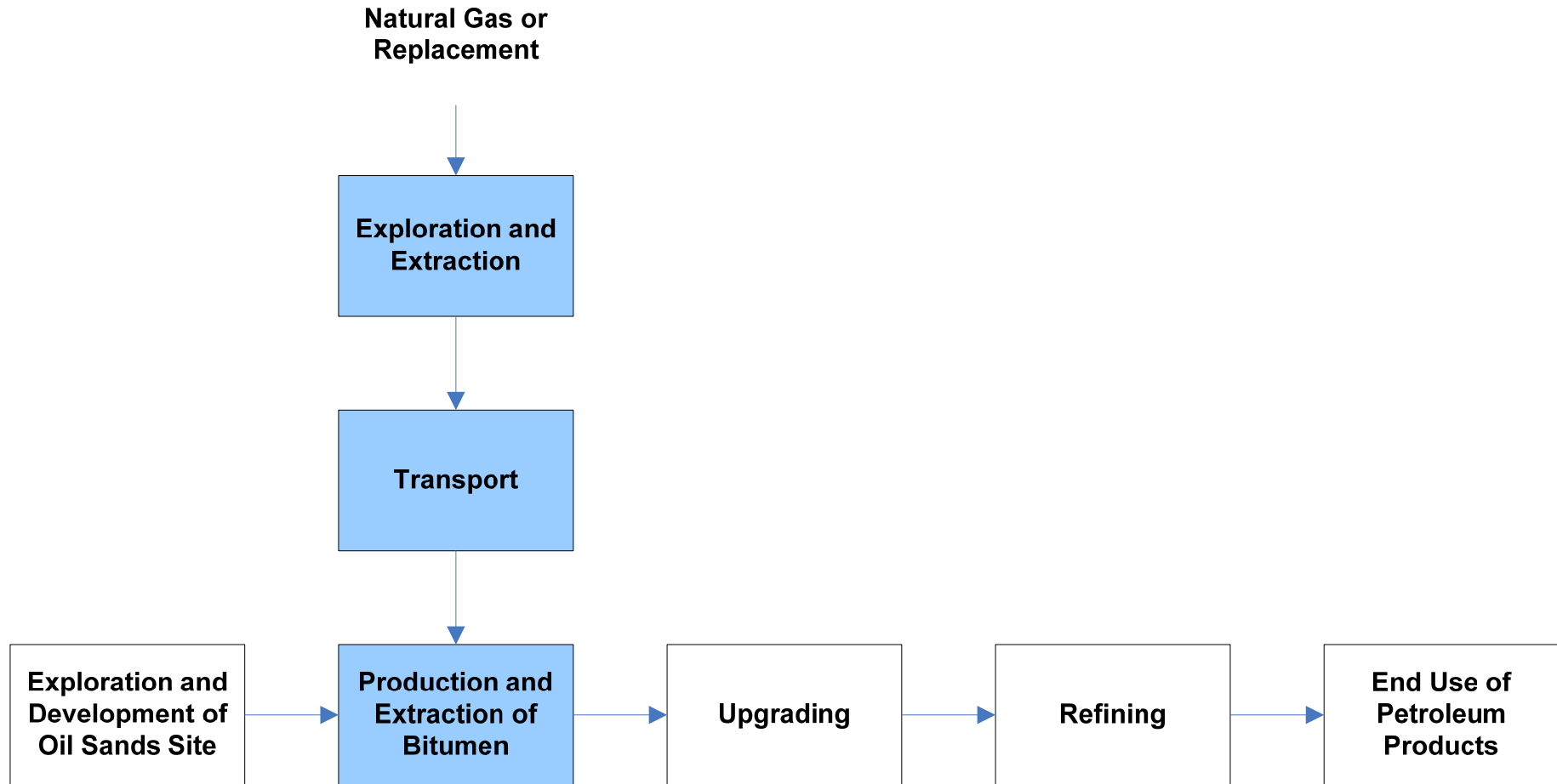


Oil Sands Life Cycle

**Natural Gas or
Replacement**

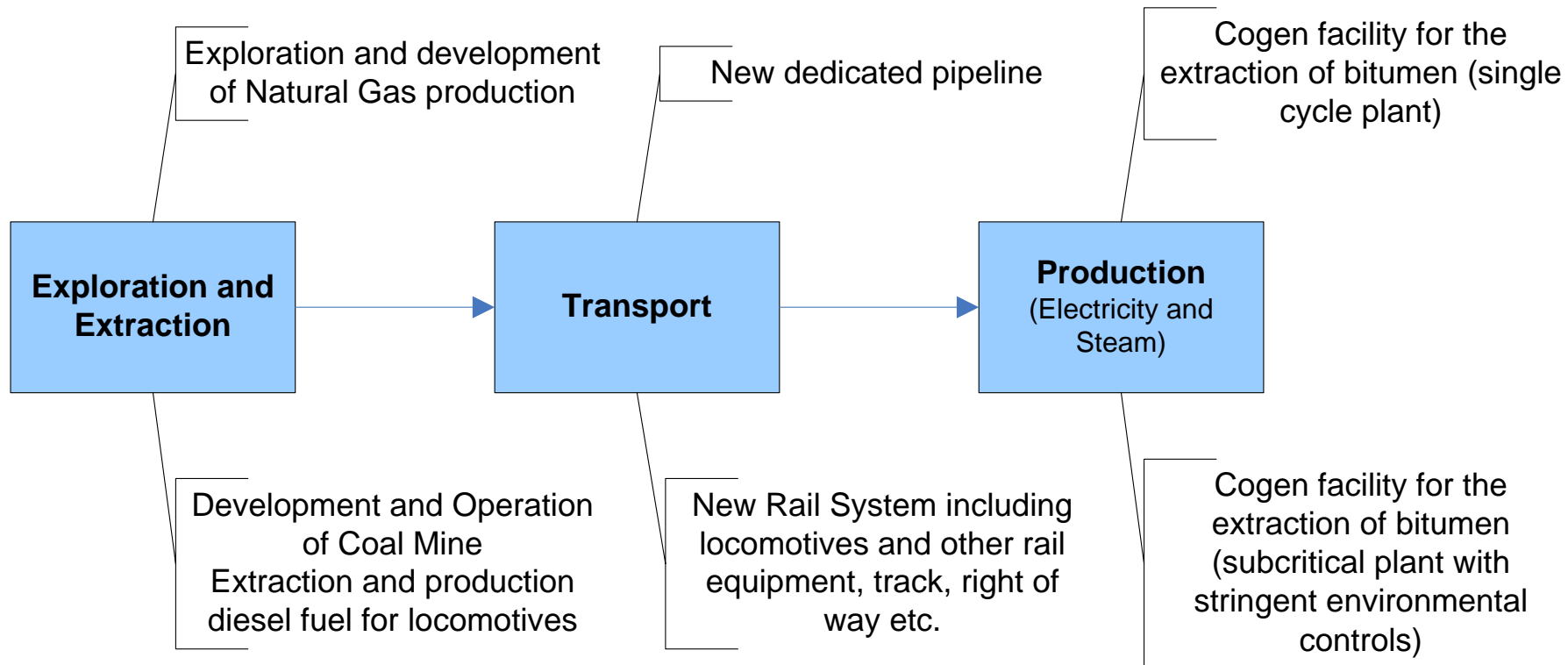


Oil Sands Life Cycle



Life Cycle Stages Considered

Natural Gas



Coal

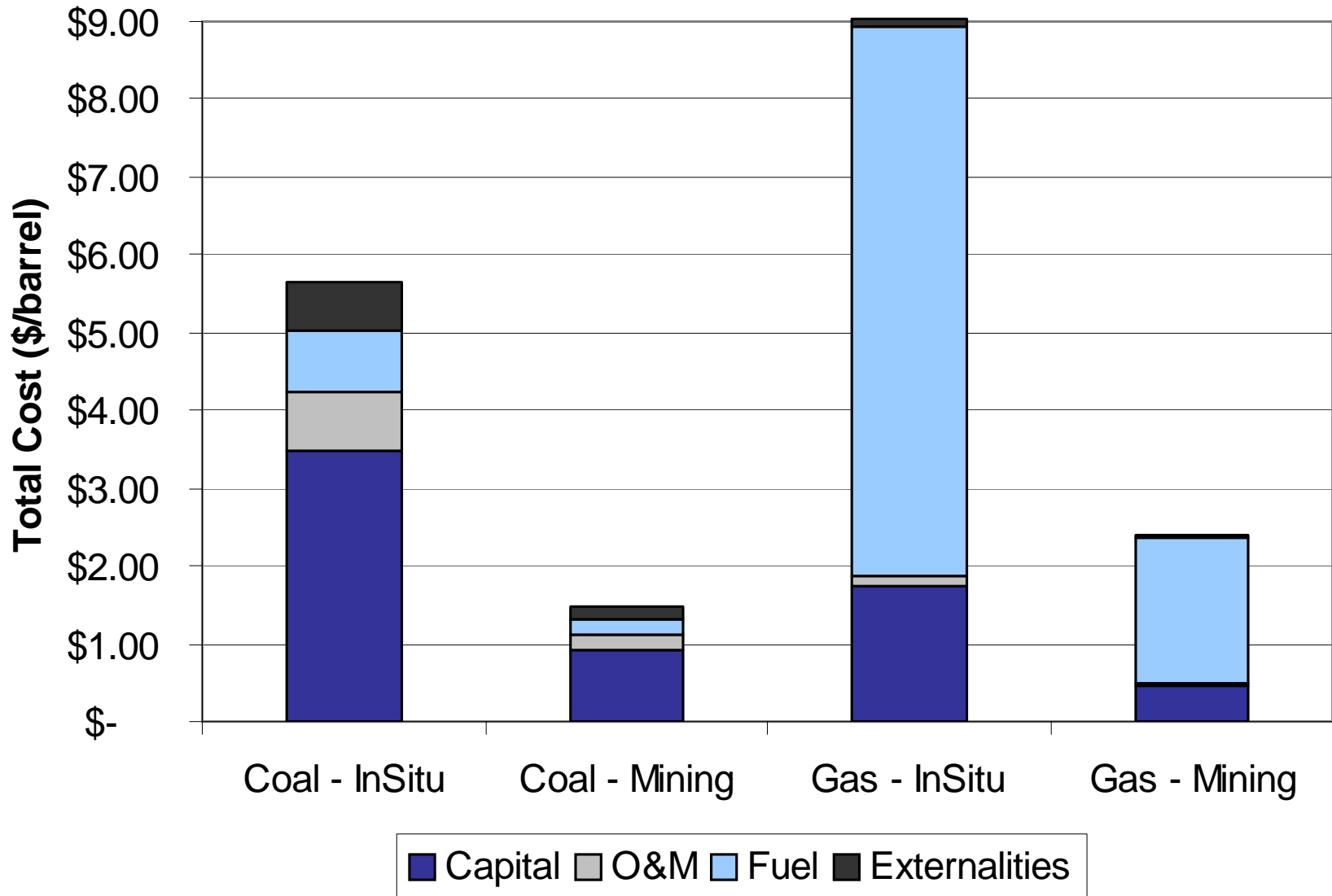
Base Case Assumptions

<u>Natural Gas</u>	
7	\$/GJ
10450	btu/kwh (single cycle gas plant)
<u>Coal</u>	
8340	btu/lb
18	GJ/ton
9996	btu/kwh (subcritical coal plant)
13	\$/ton
0.75	\$/GJ
Electricity	
0.06	\$/kwh
Externalities	
SO2	\$ 2000 / tonne
CO	\$ 520 / tonne
NO2	\$ 2800 / tonne
VOC	\$ 1600 / tonne
PM10	\$ 4300 / tonne

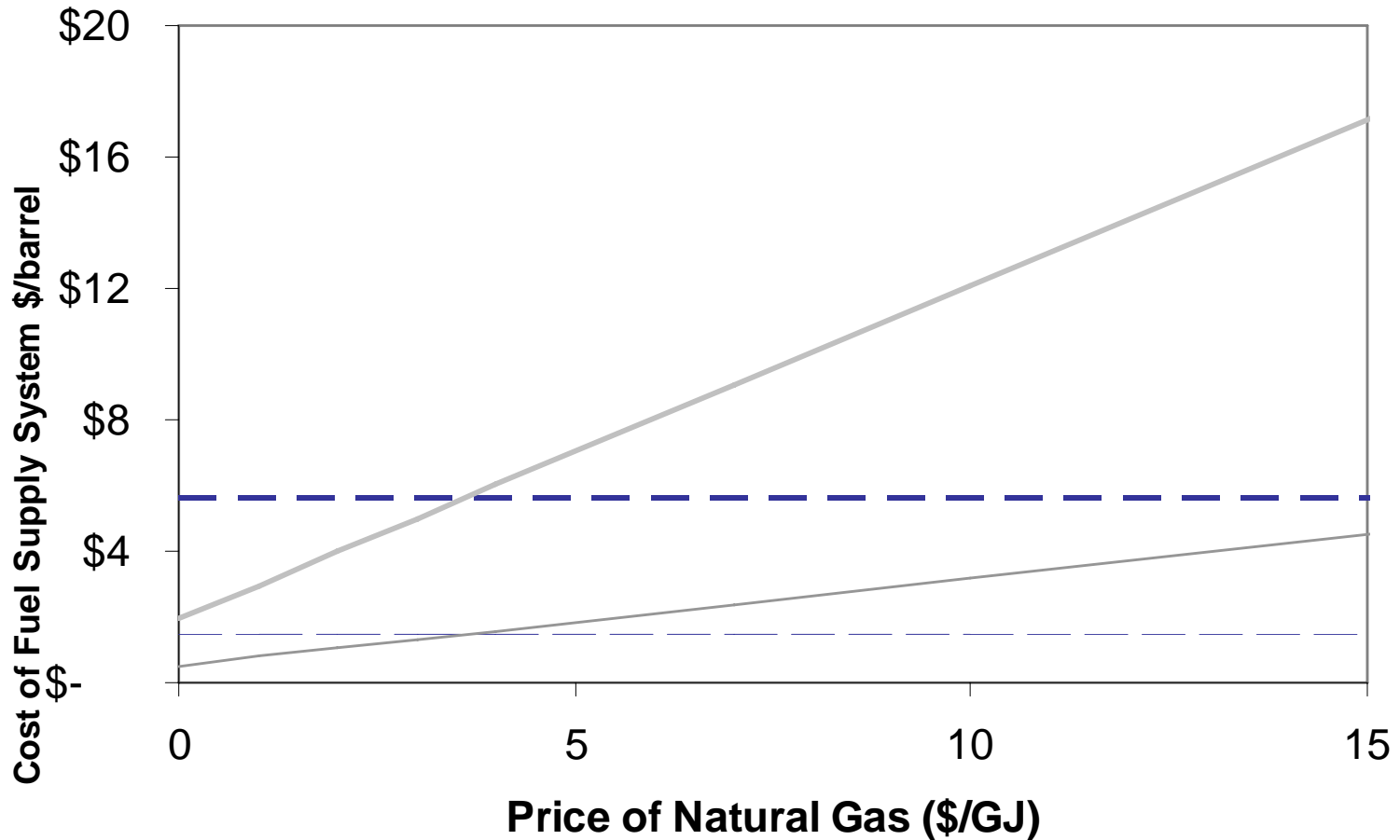
Coal vs. Natural Gas

	System Costs (\$/GJ)				Total
	Capital		O&M		
	Steam Generation	Transport of Fuel	Fuel	Other	
Coal	2	1	1	1	5 - 6
Natural Gas	1	1	7	0	8 - 10

Economic Results

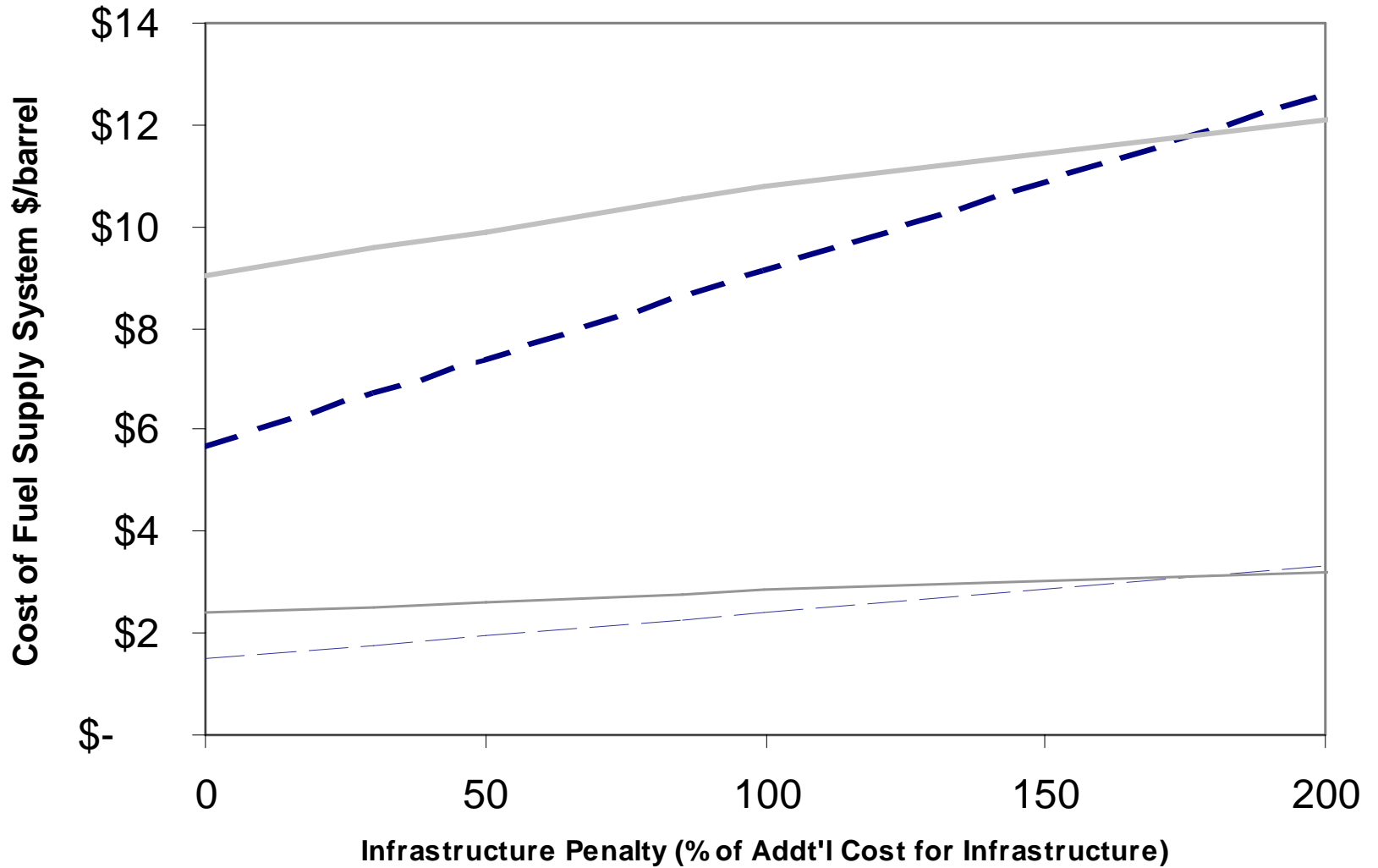


Variability in Natural Gas Prices



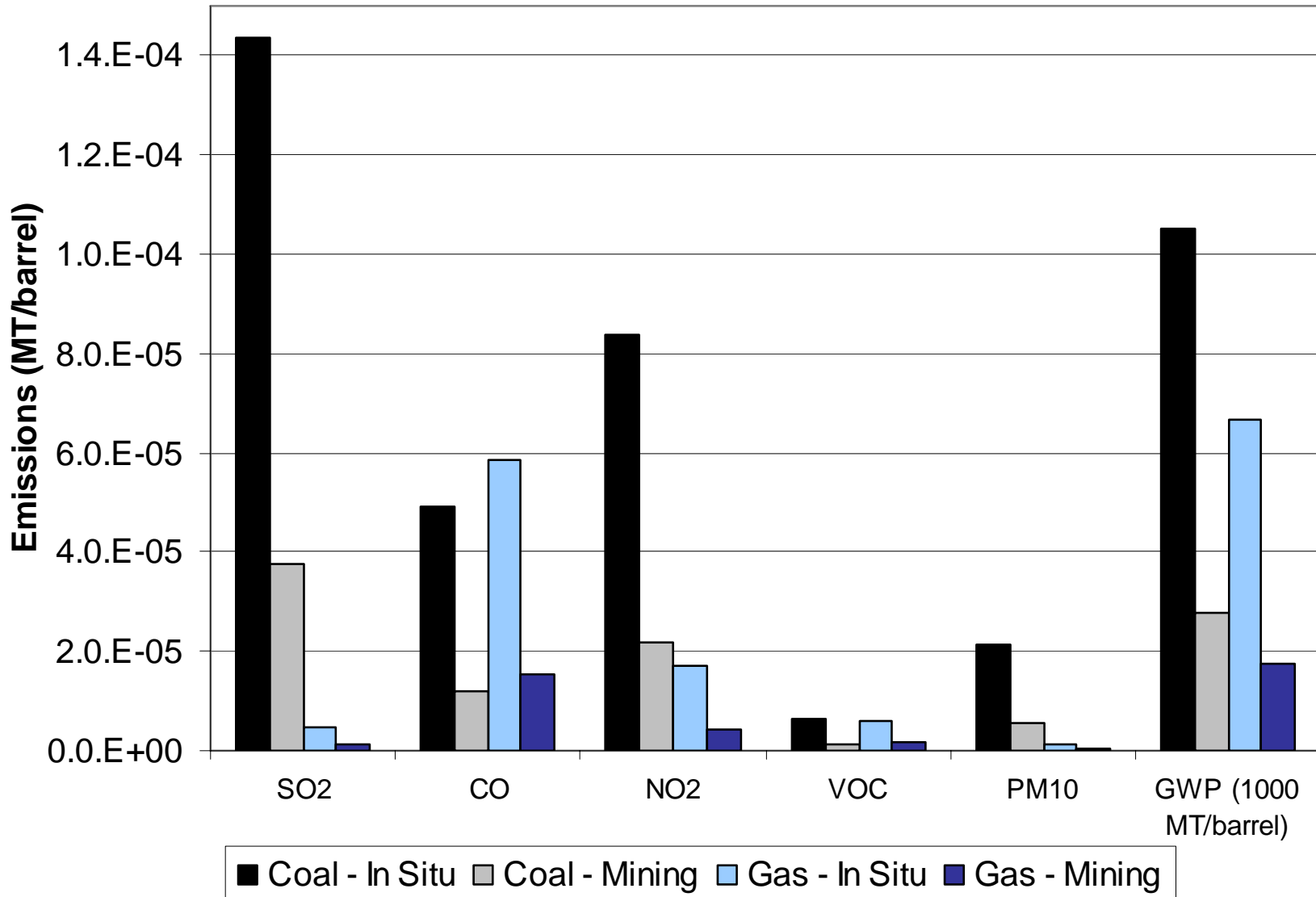
— In Situ Coal — In Situ Natural Gas — Mining Coal — Mining Natural Gas

Infrastructure Penalty



— In Situ Coal — In Situ Natural Gas — Mining Coal — Mining Natural Gas

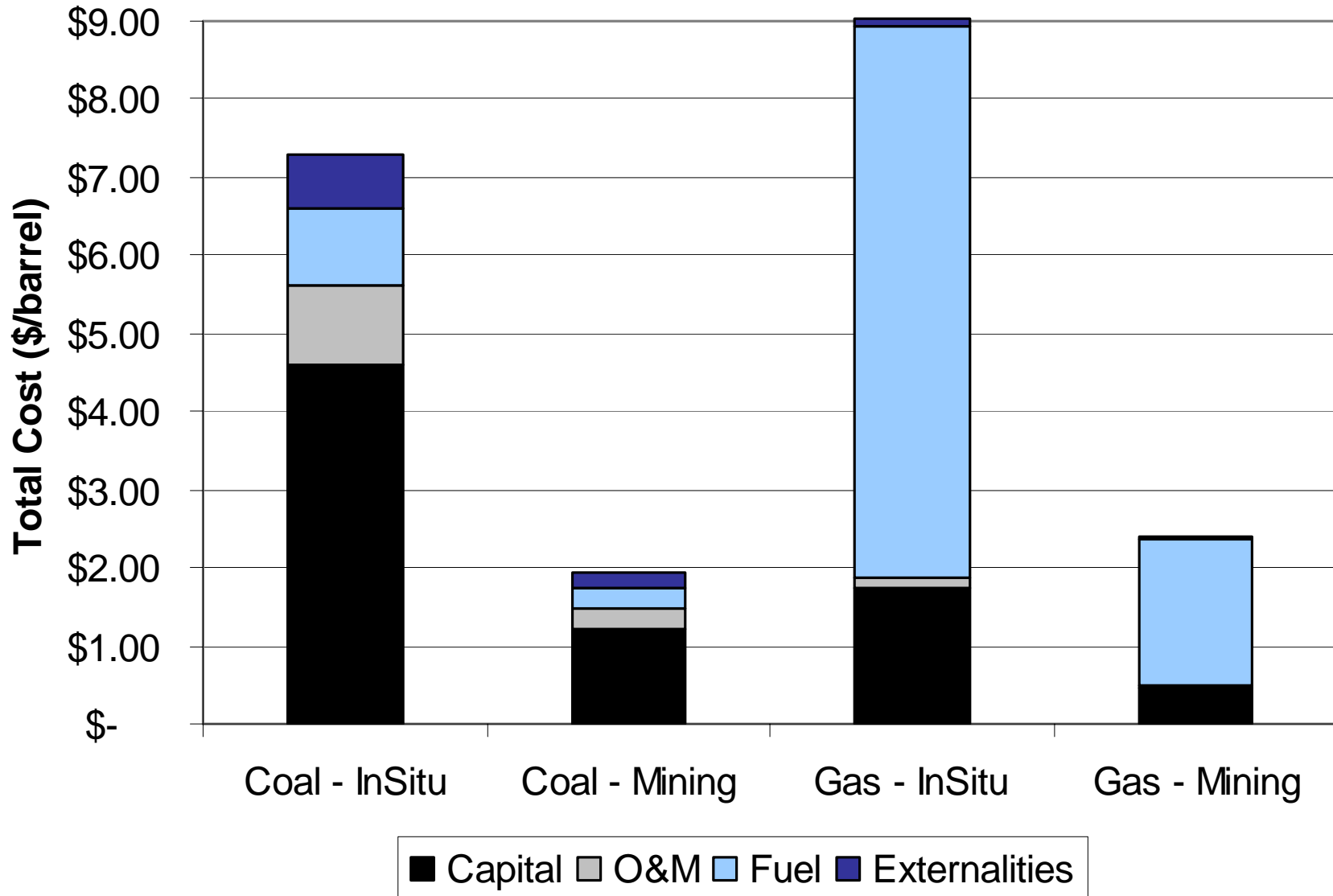
Life Cycle Emissions From Production



GHG Emissions are a concern...

- One option to reduce the impact of switching to coal is carbon capture and storage.
- Current technology operates at approximately 90% efficiency of CO₂ removal from coal power plants.
- However, this increases the cost of the coal options significantly.

Reduction of CO₂ Emissions w/ CCS



Conclusions

- Coal is an economically viable replacement for natural gas even when rail and CCS infrastructure is included.
- CCS can reduce GHG emissions from coal below those of natural gas (without CCS). However, even with stringent environmental controls in place, the overall environmental impact is worse for coal.
- While this analysis shows the difference in impacts from natural gas use between mining and in situ operations, the entire life cycle needs to be considered in order to make a decision about the two methods of extraction.

Future Work

- Continue to work on the hybrid model to improve the data.
- Addition of other alternatives (e.g. gasification of residuals - asphaltenes and coke).
- Addition of upgrading and potentially refining technologies.
- Convert all data to Canadian eiolca data as it becomes available.

Thank you

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