



Is There a Role for Nuclear Energy in Alberta's Oil Sands?

Canadian Society of Chemical Engineering
American Institute of Chemical Engineers
Edmonton, Alberta, Canada


August 14, 2003

R.B. Dunbar, P. Eng.
Canadian Energy Research Institute




Overview

- **The Canadian oil sands industry consumes large quantities of natural gas to supply its energy needs and produce hydrogen**
 - The EUB expects Alberta crude bitumen production to reach 371 10³m³/d by 2012, a 2.8-fold increase from 2002
 - Based on the configuration of currently operating projects, it is estimated that achieving this production level would require 60-75 10⁶m³/d of natural gas in 2012 - an unsustainable level
- **The industry is working hard to reduce energy requirements and/or find alternative energy sources**




CERI's Study

In response to this issue, Atomic Energy of Canada Limited (AECL) contracted the Canadian Energy Research Institute (CERI) to compare the economics of nuclear and gas-fired options to supply steam to an oil sands reservoir using SAGD




3




Study Objectives and Scope

- **Objectives**
 - Compare the economics of a modified Advanced Candu Reactor (ACR-700) with a gas-fired facility, to supply steam to a hypothetical SAGD project located in north-eastern Alberta
 - Perform the comparison at a pre-feasibility level
- **Scope**
 - The study focussed on comparative economics - it did not examine other issues that might be associated with nuclear development
 - Follow-up studies may be carried out




4




Supply Cost

- The economic comparison was made using supply cost methodology
- Supply cost is the constant dollar price that would recover all costs including:
 - Capital
 - Operating costs
 - Return on investment
- Supply cost is calculated using discounted cash flow techniques
- Supply costs for both the nuclear and the gas-fired options were calculated before tax




5

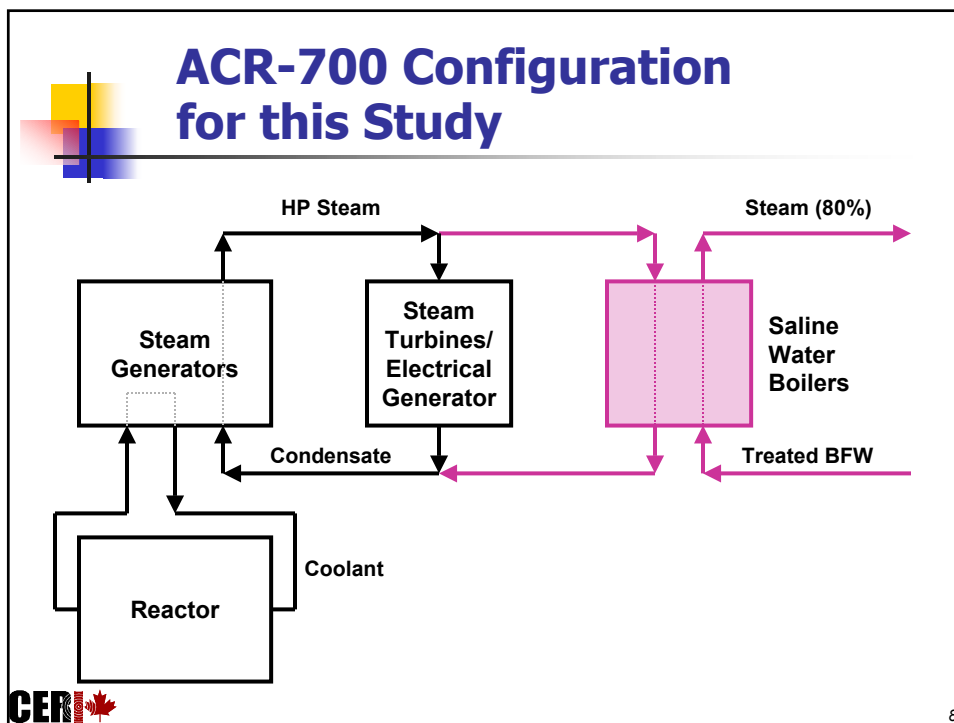
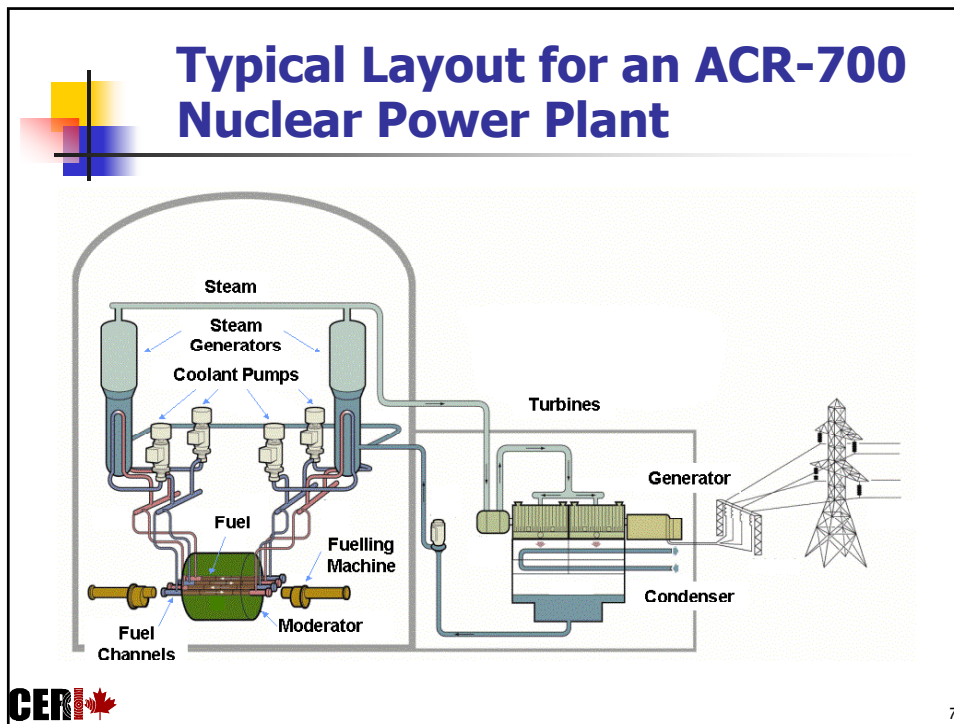


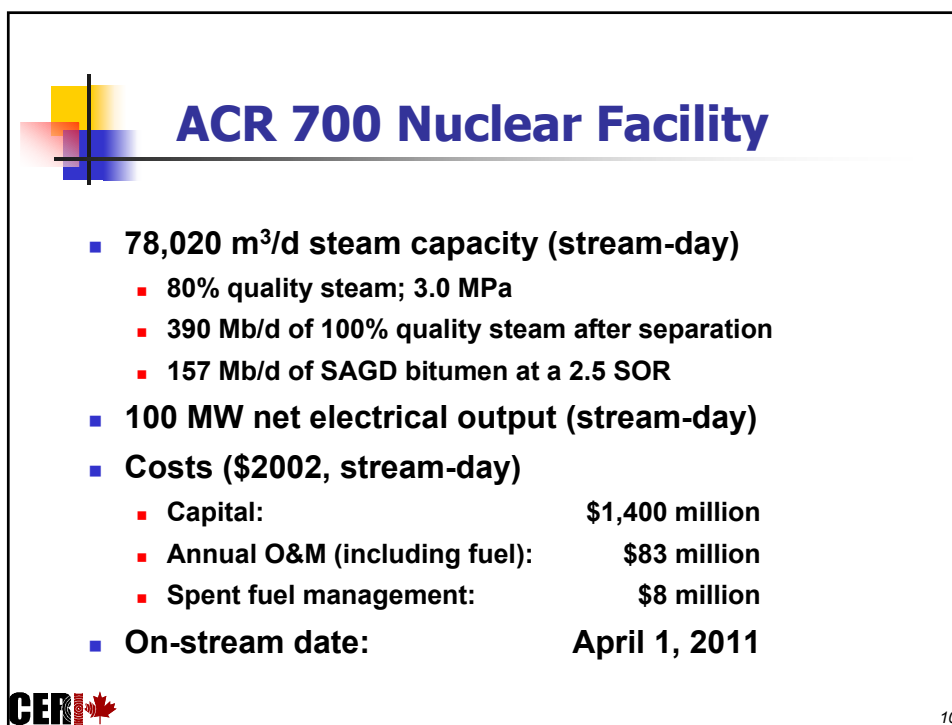
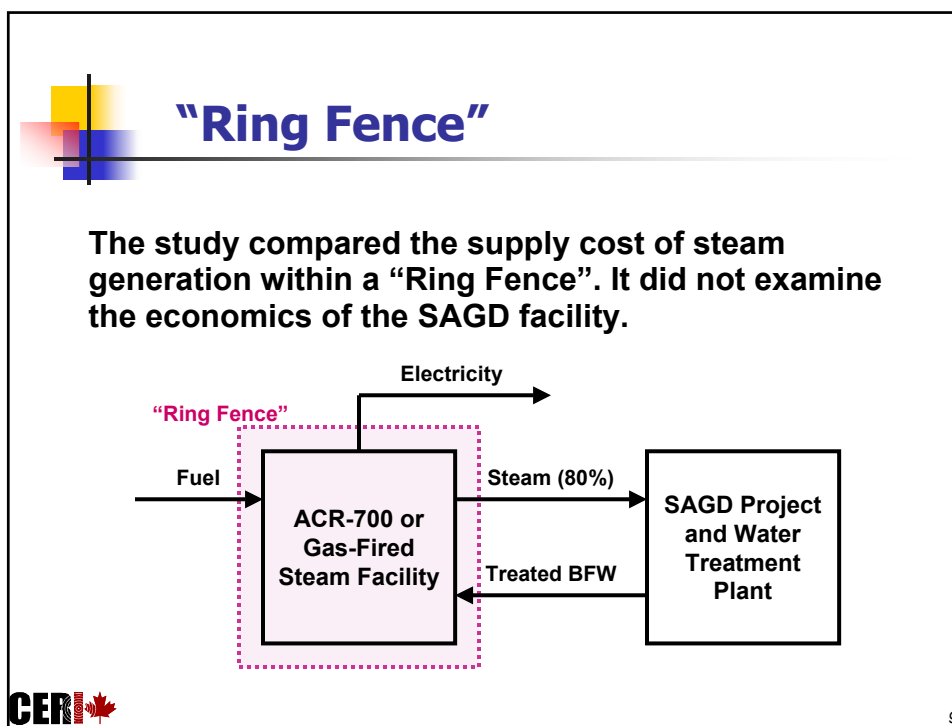
The ACR-700


- Evolutionary development of familiar CANDU technology with innovations for improvement of economics, operations and safety
- Gross output of 1983 MW_t and 728 MW_e in its normal configuration
- Slightly enriched uranium fuel
- Light water coolant
- Compact core design



6










Gas-Fired Facility

- **78,020 m³/d steam capacity and 103 MW net electrical output (stream-day)**
 - Alstom 11N2 Gas Turbine with electrical generator and HRSG (116.5 MW_e ISO rating)
 - 21 OTSGs (36.33 kg/s steam capacity per unit)
- **Costs (\$2002, stream-day)**
 - Capital: \$230 million
 - Annual O&M: \$8.5 million
 - Annual fuel: \$256 million
- **On-stream date: April 1, 2011**


11



Energy Price Assumptions

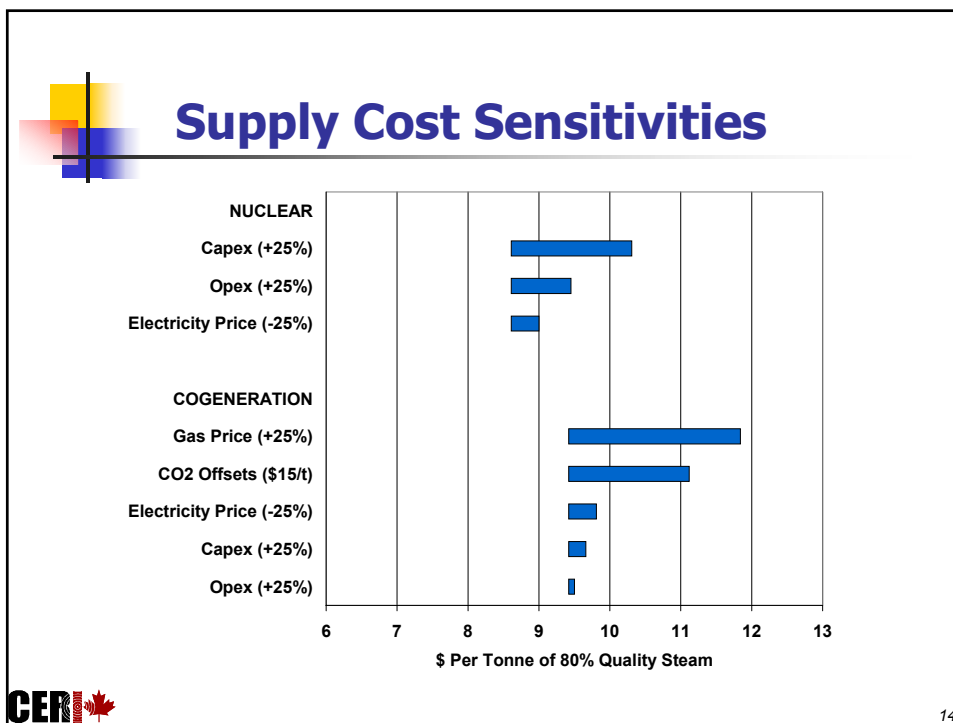
- **Natural Gas**
 - NYMEX: US\$3.50/MMBtu
 - Plant Gate: C\$4.25/GJ
- **Electricity**
 - Plant Gate: C\$50/MWh

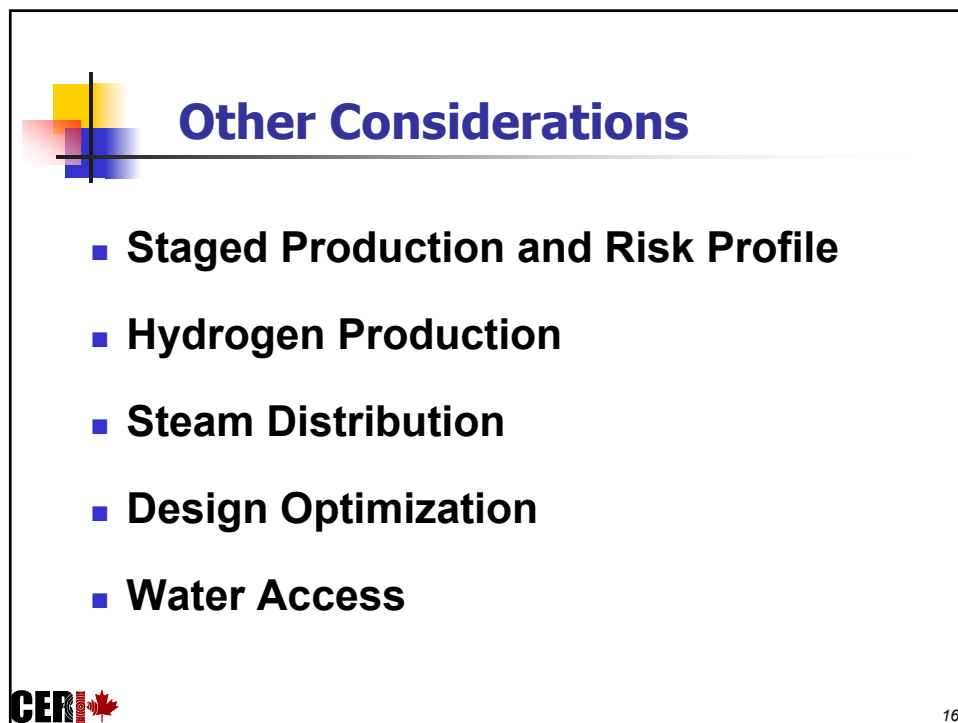
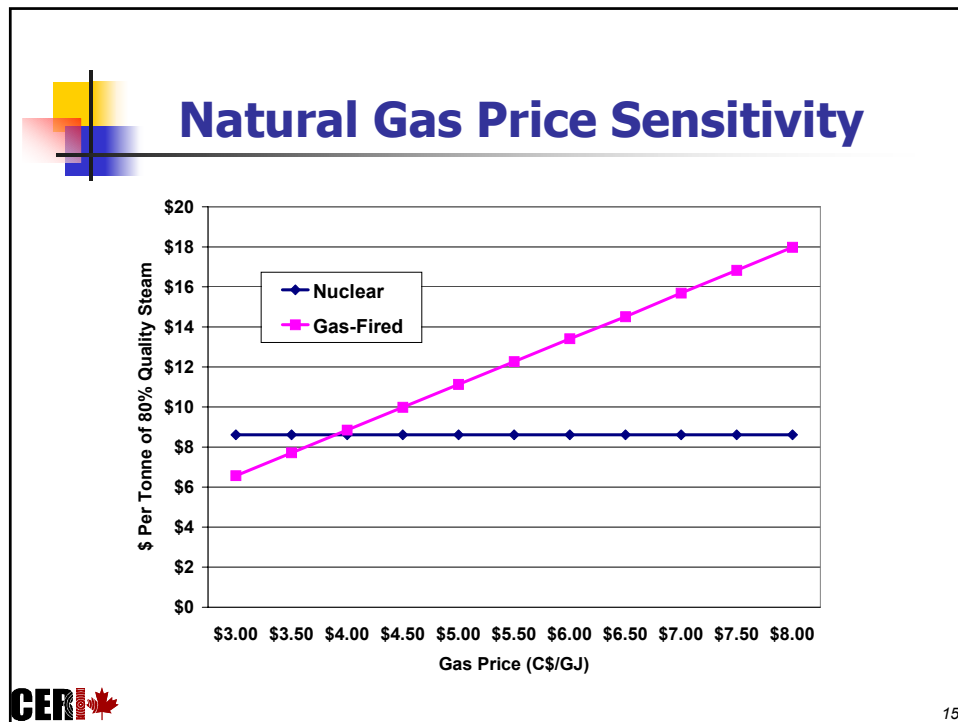

12

Steam Supply Costs - Base Case (C\$/t)

	Nuclear Option	Gas-Fired Option
Costs		
Fixed Capital	6.71	0.96
Working Capital	0.09	0.01
Fuel	included	9.70
Spent Fuel Management	0.28	0.00
Other Operating Costs	<u>3.07</u>	<u>0.33</u>
Subtotal	10.15	11.00
Credits		
Electricity Sales	1.54	1.58
Total Supply Cost	8.61	9.42

CERI  13







Conclusions (1)

- Steam supply from an ACR-700 nuclear facility would be economically competitive with steam supply from a gas-fired facility
- Based on the configuration studied, the ACR-700 nuclear facility would support a very large SAGD project (23,200 m³/d) - adequate bitumen reserves to support this scale of operations would need to be located within reasonable proximity of the central steam generation site



17



Conclusions (2)

- Steam supply cost from a nuclear facility is very sensitive to capital cost
- Steam supply cost from a gas-fired facility is very sensitive to natural gas price and possible Kyoto compliance cost



18