Canadian Clean Power Coalition:
Clean Coal-Fired Power Plant Technology
To Address Climate Change Concerns

Presented to
Gasification Technologies 2003
San Francisco, CA
October 13 to 15, 2003

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Chair, CCPC Technical Committee
The Canadian Clean Power Coalition

• A national association of coal and coal-fired electricity producers

• Represents over 90 percent of Canada’s coal-fired electricity generation

• Objective is to demonstrate that coal-fired electricity generation can effectively address all environmental issues projected in the future, including CO₂
Coalition Participants

- ATCO Power Canada Ltd.
- EPCOR Utilities Inc.
- EPRI (Electric Power Research Institute)
- IEA (GHG and CCC)
- Luscar Ltd.
- Nova Scotia Power Inc.
- Ontario Power Generation Inc.
- Saskatchewan Power Corporation
- TransAlta Utilities Corporation
Government Participation

- Natural Resources Canada
- Alberta Energy Research Institute
- Saskatchewan Industry and Resources
CCPC Plan: Demonstration of $\text{CO}_2$ Extraction From Power Plants

- Construct and operate a full-scale demonstration project to remove greenhouse gas and all other emissions of concern from an existing coal-fired power plant by 2007 – “Retrofit Case”

- Demonstrate a low emission technology for new power plants by 2010

- Range of fuels includes bituminous, sub-bituminous, lignite.
Retrofit Options for CO₂ Extraction

• Options evaluated:
  – Amine scrubbing of flue gas
  – CO₂/O₂ Combustion

• Major challenges to reduce auxiliary energy requirements

• Focus on integration options
Flue Gas Amine Scrubbing

Issues
- High amine regeneration heat load
- Fate of mercury in amine system
CO₂/ O₂ Combustion

Issues
- Boiler performance with recycle flue gas
- Air entrainment
- Shaft power for ASU
- Quality of CO₂
Greenfield Plant Technology Options

- Pre-screening study showed gasification as best option
- Provides high efficiency, ease of emission reduction and lowest energy penalty to add CO₂ capture
- Efficiency improvements from new advanced gas turbines
Coal Gasification - IGCC with CO₂ Capture

Dry or slurry feed

Air

Coal Preparation

Gasifier

Gas Cooling

Gas Cleaning

Shift Reactor

CO₂ Extraction

CO₂ Cleanup & Compression

Nitrogen

Oxygen

Slag

Sulphur

Flue Gas To Atmosphere

Steam Turbine

Waste Heat Boiler

Gas Turbine

Electric Power

Electric Power

CO₂ to Pipeline

Hydrogen
IGCC Issues

- Gasification characteristics of bituminous, subbituminous and lignite coals
- Gasifier feed systems: wet vs dry vs CO\textsubscript{2} slurry
- Syngas composition, clean-up, fate of mercury
- Purity specifications of captured CO\textsubscript{2}
- Reliability of gasification plant to meet power generation service factors
- Integration of plant components to minimize capital costs and optimum performance
CO₂ Utilization & Storage Evaluation

• Reviewed prior work on EOR & ECBM use in western sedimentary basin

• Separate study for Nova Scotia to examine potential for ECBM in coal beds

• Evaluation of storage options in deep saline aquifers and depleted reservoirs
Emissions Control Study

• Looked at retrofit emission control for NOx, SOx, Hg, particulates and all other pollutants

• Excluded CO₂

• Allows net costs for CO₂ to be calculated by comparison with the other studies
Project Status

- Pre-screening study completed early 2002
- Control options for emissions all except CO$_2$ completed December 2002
- Studies to assess technology options and costs for retrofit plant options and greenfield plant options completed July 2003
- Examination of CO$_2$ utilization and storage completed August 2003 (Nova Scotia portion expected October 2003)
Plants selected for comparative evaluation

• Trenton # 6, a 150 MWe bituminous coal fired power plant located in Nova Scotia
• Shand, a 300 MWe lignite coal fired power plant located in Saskatchewan
• Genesee, a 400 MWe sub-bituminous coal fired power plant located in Alberta
Evaluation of Retrofit Plants for all Emissions Except CO$_2$

- **LONox Burners**
  - Combustion - 60% NOx removal

- **SCR**
  - 95% NOx removal

- **ESP**
  - 99% particulate removal
  - Carbon injection 0.07lb/MBtu

- **COHPAC**
  - 90% Hg removal: 99.9% particulate removal

- **FGD**
  - 98% Sox removal; 90% Hg removal

- **WESP**
  - 90% particulate removal
Retrofit Plants for all Emissions Except CO₂ - Capital Costs

- Marsulex
- Airborne
- LSFO
- Toxecon

C$/kW

Lignite  Sub-bit  Bituminous
Retrofit Plants for all Emissions Except CO₂ - O&M Costs

- Marsulex
- Airborne
- LSFO
- Toxecon

C$/MWh

Lignite, Sub-bit, Bituminous
Retrofit Plants: 90% CO₂ Removal
Pollutant Removal Efficiencies

% Removed

- NOx
- SOx
- PM
- Hg

- Lignite
- Sub-bit
- Bituminous
Capital Cost Comparisons with CO₂ Capture

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C$/kW
Cost of Electricity Comparisons with CO₂ Capture

- Lig. Amine
- Lig. Oxyfuel
- Lig. Gasif.
- Sub-Bit. Gasif.
- Bit. Gasif.
Cost of CO₂ Avoided Comparisons

- Lig. Amine
- Lig. Oxyfuel
- Lig. Gasif.
- Sub-Bit. Gasif.
- Bit. Gasif.

C$/tonne
Options for CO$_2$ Utilization & Storage

- Enhanced oil recovery (EOR)
- Enhanced coal bed methane recovery (ECBM)
- Storage in depleted oil & gas reservoirs
- Storage in deep saline aquifers

All are deemed realistic and technically feasible in the Western Canadian Sedimentary Basin.
Assumptions for CO₂ Utilization & Storage

• Store output from 400 MW power plant - 78Mt over 30 years
• Clean CO₂ at plant gate at 13.7 MPa
• Pipelines included:
  – EOR - 200 km
  – ECBM - 100 km
  – Geological storage - 75 km
• Oil price of US$20/barrel, natural gas @ $3.74/GJ
Economics for CO₂ Utilization & Storage

- An EOR project could pay $38/tonne for CO₂
- An ECBM project could pay $10/tonne for CO₂
- Geological storage would require a credit of $4/tonne
In Summary

- The Canadian Clean Power Coalition is moving forward with plans to demonstrate clean coal power generation at a new plant by 2010.
- The CCPC is an industry/government partnership among the Canadian coal industry, federal and provincial governments.
- Phase 1 has expanded to include international participation with the addition of the IEA and EPRI.
- Phase 1 (CAN$5,000,000) will be complete in late 2003.
- The goal is to maintain coal as a key option for power generation in Canada, while meeting all environmental concerns about its use.