

**Canadian Clean Power Coalition:  
Current Status of Clean Coal Technologies**

Presented to

**National Energy Board**

**Calgary, AB**

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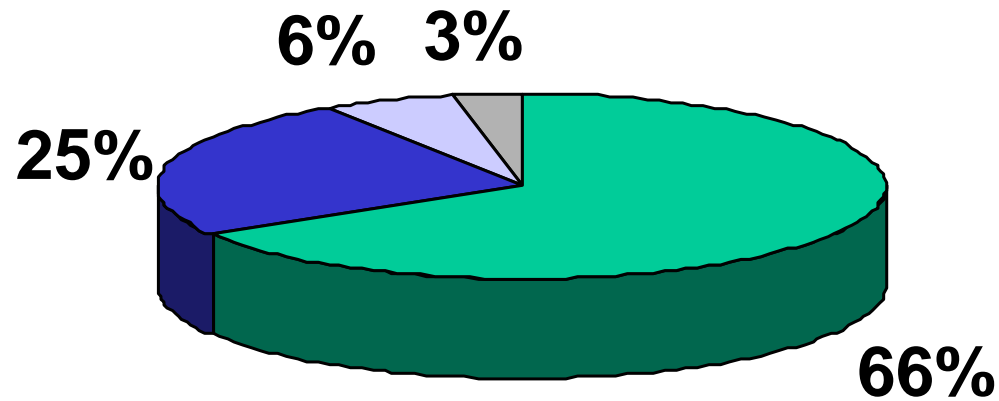
**Executive Director, CCPC**

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# Presentation Outline

- Canadian Clean Power Coalition Overview
- Phase I Studies
- Phase II Status
  - Gasification Technologies
  - ASC Technologies

## Canada's Fossil Fuel Energy Reserves



 Coal  Oil Sands Bitumen  Gas  Conventional Oil

# The Canadian Clean Power Coalition

- Formed in 2000
- A national association of Canadian coal and coal-fired electricity producers
- Represents over 90 percent of Canada's coal-fired electricity generation
- Industry/government partnership
- Objective is to demonstrate that coal-fired electricity generation can effectively address all environmental issues projected in the future, **including CO<sub>2</sub>**

[www.canadiancleanpowercoalition.com](http://www.canadiancleanpowercoalition.com)

## Current Coalition Participants

- ATCO Power Canada Ltd.
- Basin Electric Power Cooperative (North Dakota)
- EPCOR Utilities Inc.
- EPRI (Electric Power Research Institute)
- Luscar Ltd.
- Nova Scotia Power Inc.
- Saskatchewan Power Corporation
- TransAlta Corporation

In addition, in Phase I, IEA (GHG and CCC) and Ontario Power Generation Inc. participated

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# Government Participation

- Natural Resources Canada
- Alberta Energy Research Institute
- Saskatchewan Industry and Resources

# CCPC Goal: Build and Operate a Clean Coal Demonstration Plant

- Construct and operate a full-scale demonstration project to remove greenhouse gas and all other emissions of concern from a coal-fired power plant by 2012
- Provide flexible fuel capability– bituminous, sub-bituminous, lignite, and petroleum coke
- To accomplish this at a competitive cost of power

# CCPC Plan

 2000: Formation & planning

 2001 - 2003: Phase I technology studies

 2004: Results assessment and Phase II formation

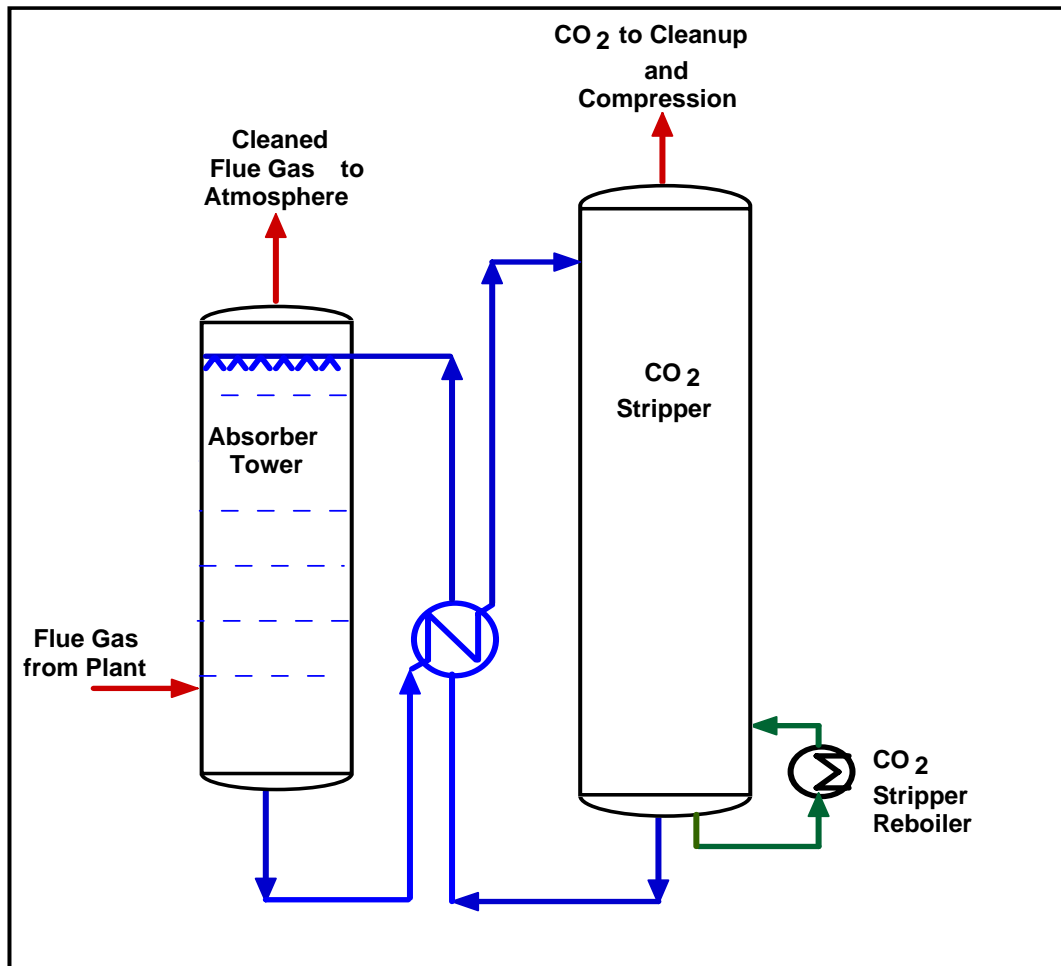
 2004 - 2006: Phase II optimization studies

2006: Status assessment & commitment to demo project

2007 – 2011: Design & construction (and 2009 – 2014)

2012 & 2015: Operation

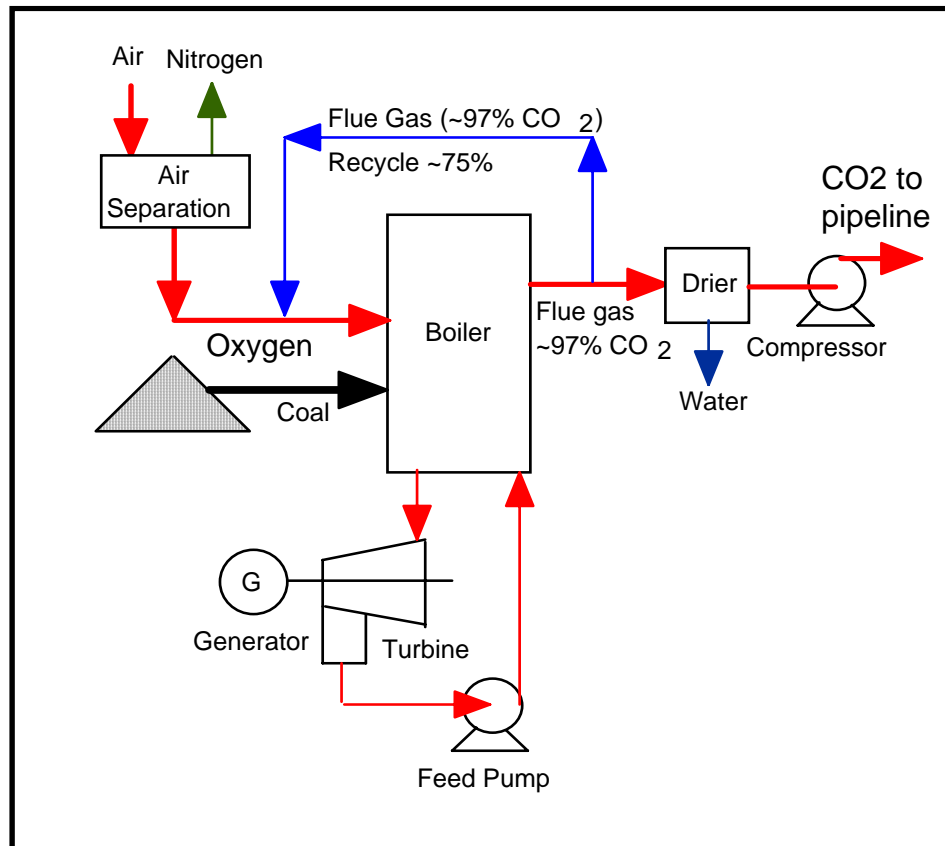
# Flue Gas Amine Scrubbing



## Issues

- High amine regeneration heat load
- Fate of mercury in amine system

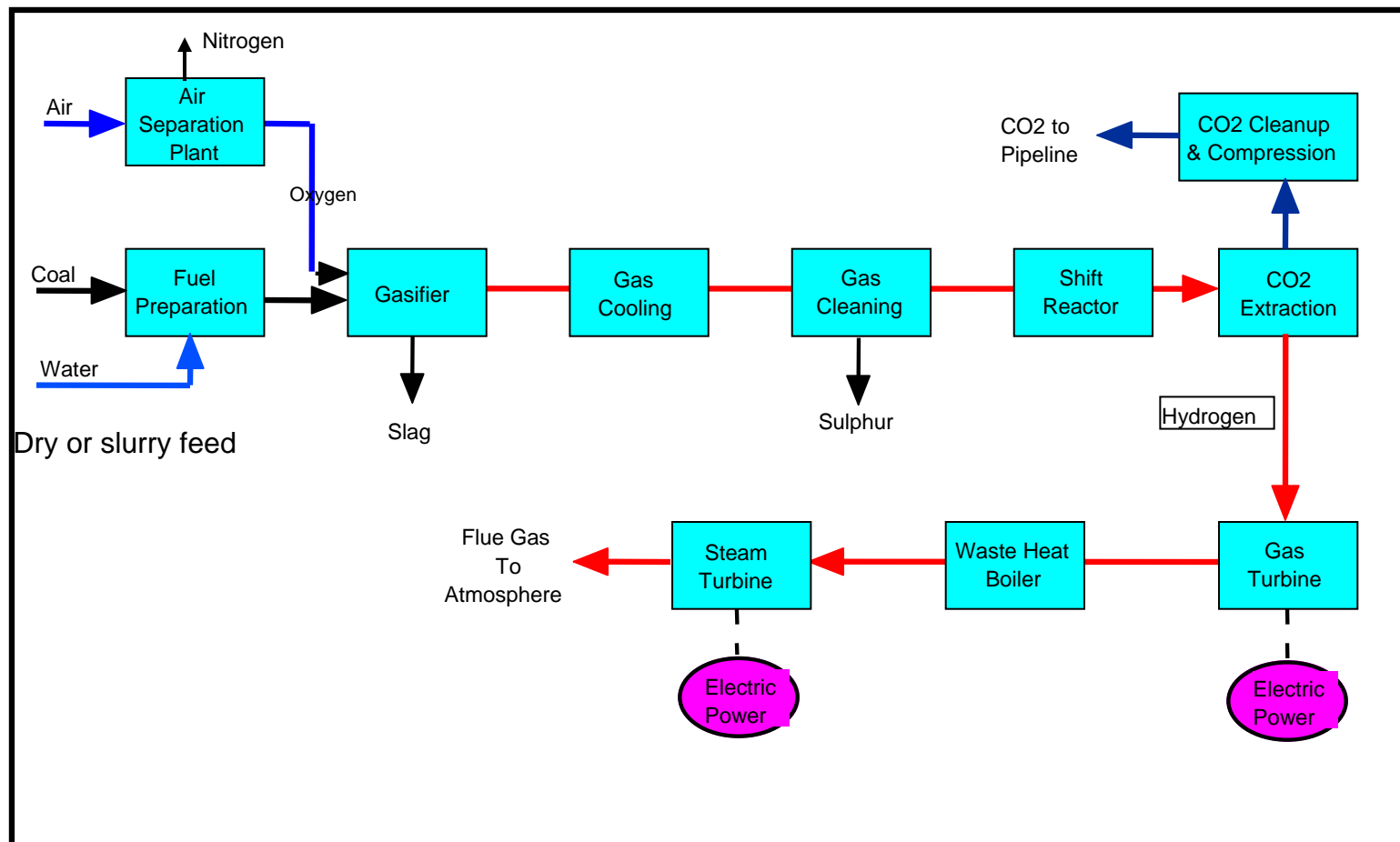
# CO<sub>2</sub>/O<sub>2</sub> Combustion



## Issues

- Boiler performance with recycle flue gas
- Air entrainment
- Shaft power for ASU
- Quality of CO<sub>2</sub>

# Coal Gasification- IGCC with CO<sub>2</sub> Capture



## IGCC Issues

- Gasification characteristics of bituminous, sub-bituminous and lignite coals
- Gasifier feed systems: wet vs dry vs CO<sub>2</sub> slurry
- Syngas composition, clean-up, fate of mercury
- Purity specifications of captured CO<sub>2</sub>
- Reliability of gasification plant to meet power generation service factors
- Integration of plant components to minimize capital costs and optimum performance

# Emissions Control Study

- Looked at retrofit emission control for NO<sub>x</sub>, SO<sub>x</sub>, Hg, particulates and all other pollutants
- Excluded CO<sub>2</sub>
- Allows net costs for CO<sub>2</sub> to be calculated by comparison with the other studies

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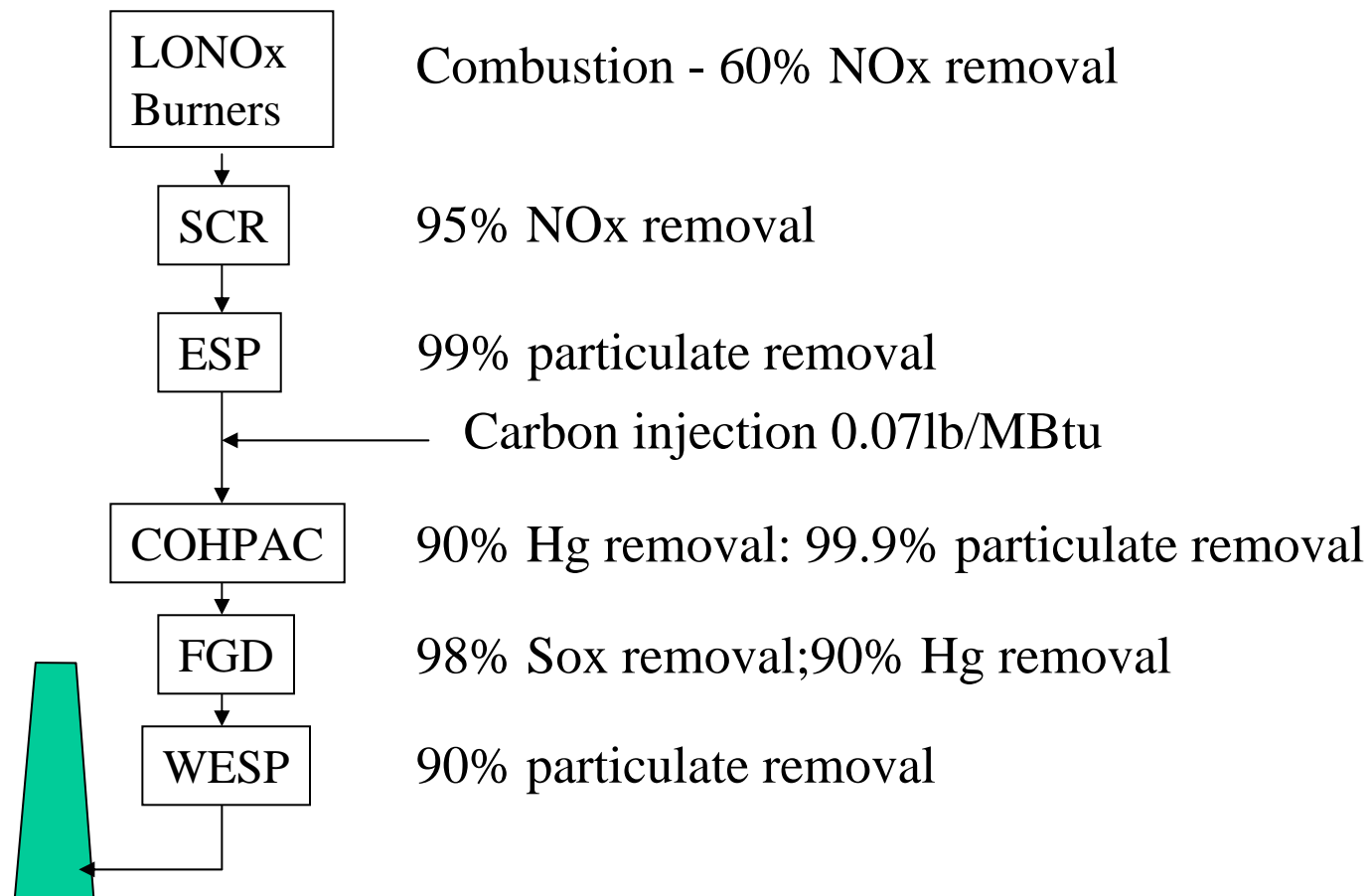
# Plants selected for comparative evaluation

- 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

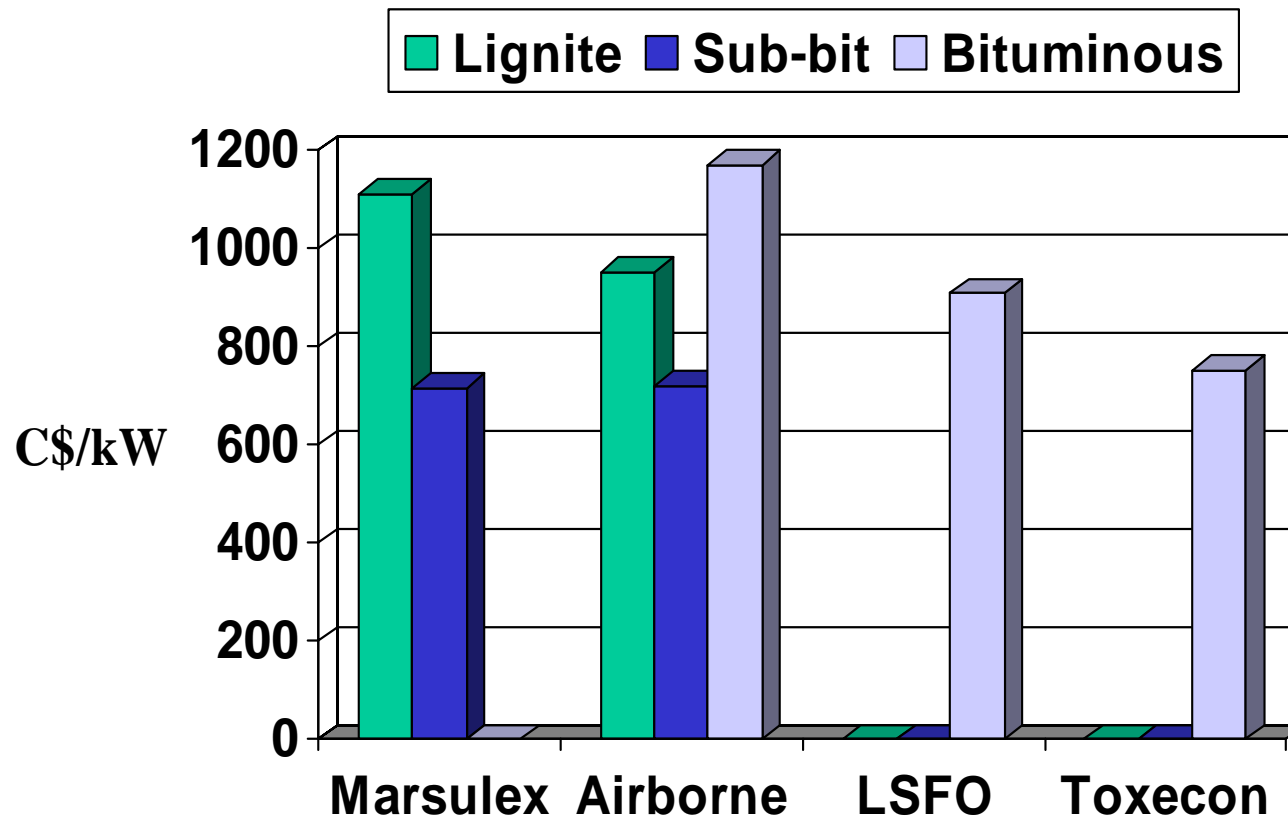
# Target Emission Levels-Comparison with Natural Gas Combined Cycle (NGCC)

Type	Units	Lignite	Sub-bit	Bituminous	NGCC
NO <sub>x</sub>	Gram/MWh net	27.6	27.6	27.6	27.6
SO <sub>x</sub>	Ng/Joules fired	0.7	0.7	0.7	0.7
PM <sub>10, 2.5</sub>	Ng/Joule fired	2	2	2	2
Mercury	Pg/J	0.5	0.3	0.3	N/A
CO	ppm @ 3% O <sub>2</sub>	40	40	40	45
SO <sub>3</sub>	ppmv	5	5	5	N/A
NH <sub>3</sub>	ppmv	1	1	1	1
Heavy Metals					
Se		6	6	6	
As	Mg/Nm <sup>3</sup>	6	6	6	
Cd		2	2	2	

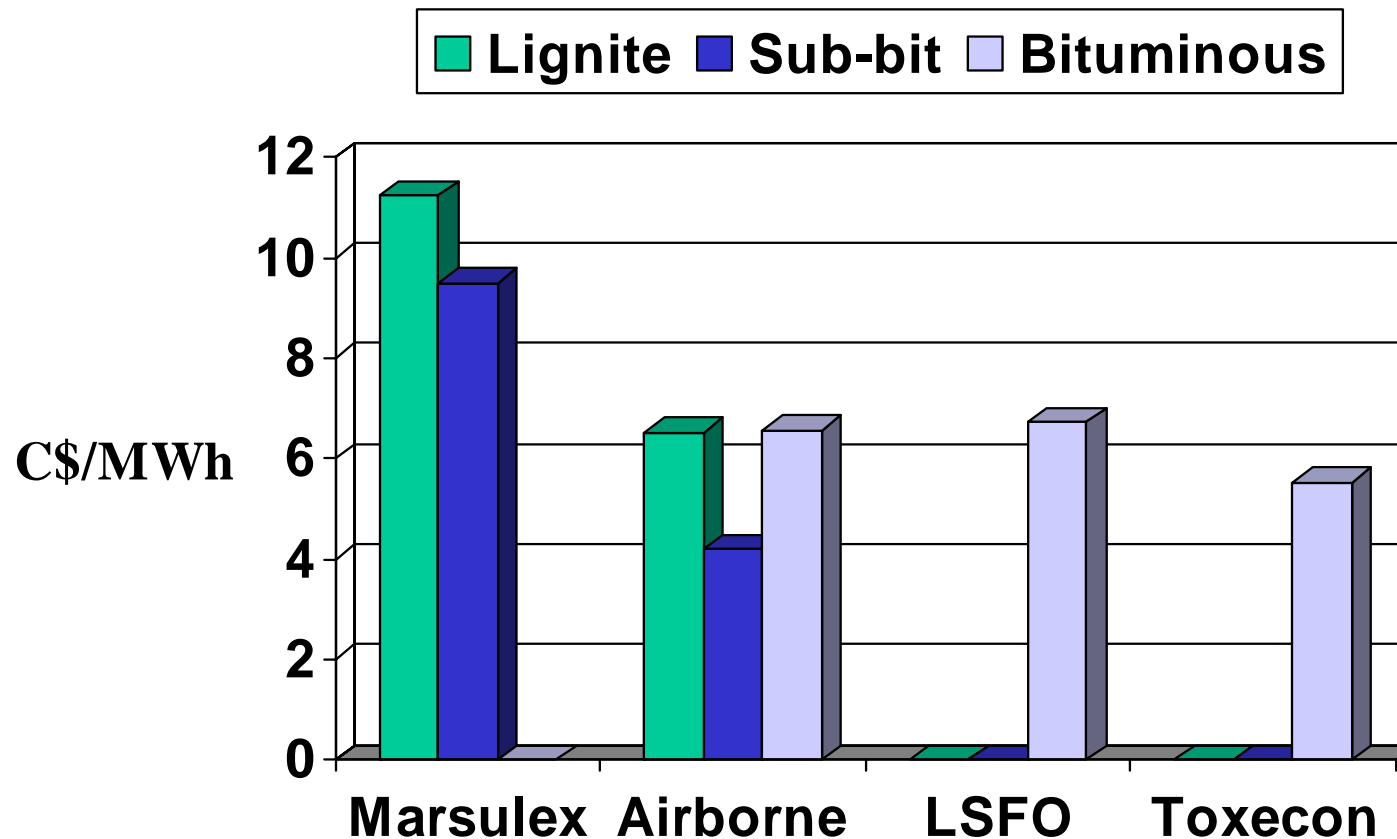
# Evaluation of Retrofit Plants for all Emissions Except CO<sub>2</sub>



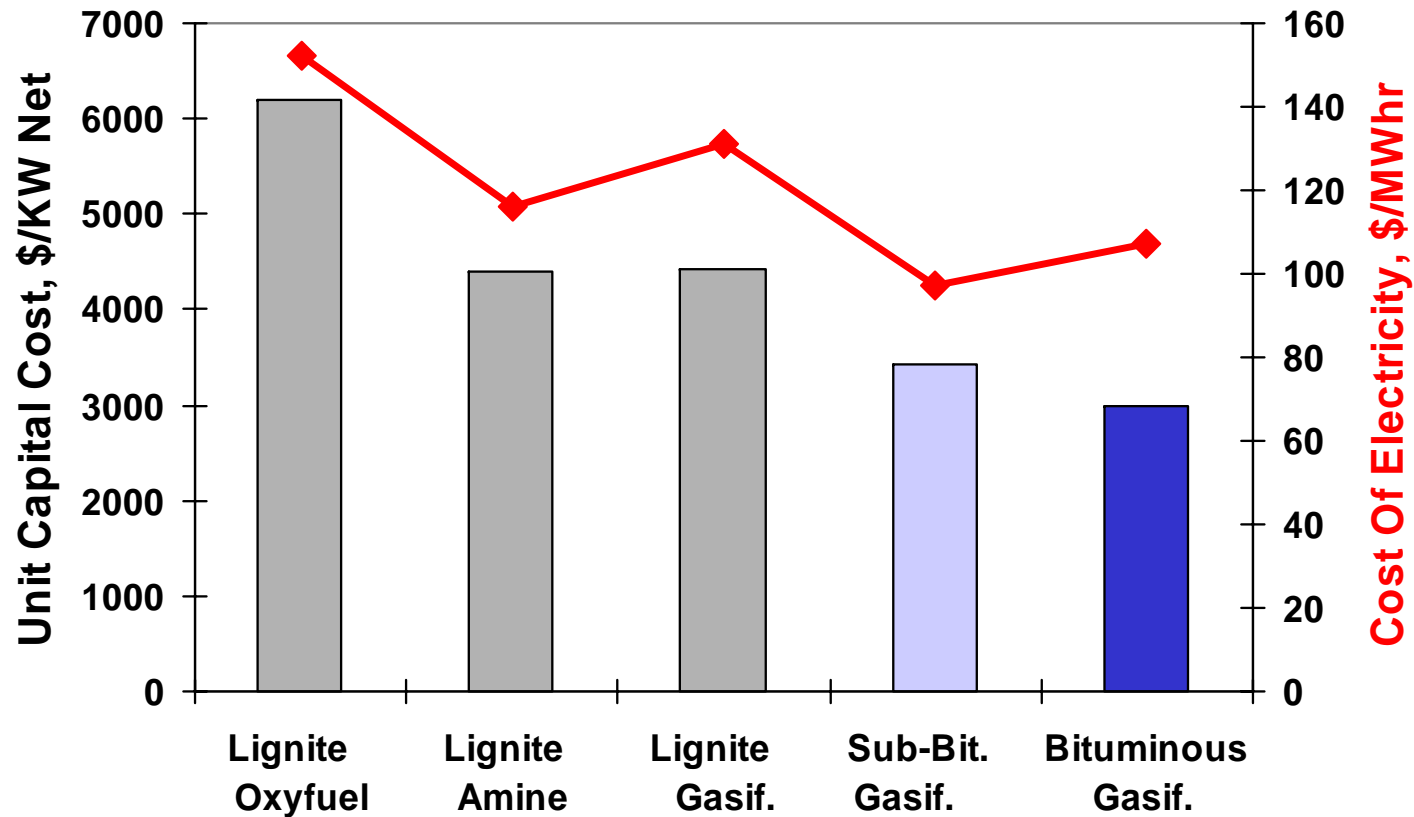
# Retrofit Plants for all Emissions Except CO<sub>2</sub> - Capital Costs



# Retrofit Plants for all Emissions Except CO<sub>2</sub> - O&M Costs



# Unit Capital Cost & Cost of Electricity Comparisons for 90 % CO<sub>2</sub> Capture



## CCPC – Phase I Results

- Texaco Quench evaluated for Pittsburgh # 8 and sub-bituminous coal but Texaco declined to provide data for lignite. Shell selected for lignite.
- Fluor has improved the design of their Econamine (MEA) process for flue gas removal of CO<sub>2</sub> reducing the energy penalty from ~1750 to ~1185 Btu of steam/lb of CO<sub>2</sub>.
- Although the cost of CO<sub>2</sub> avoided is lower for IGCC than for amine scrubbing for the bituminous and sub-bituminous coals at grass roots plants the differential is less than with previous studies
- For lignite Shell IGCC with pre combustion CO<sub>2</sub> removal was worse than amine scrubbing. All current commercial gasification technologies have poor performance with low rank and high ash coals
- Oxyfuel (O<sub>2</sub> with recycle CO<sub>2</sub>) was evaluated to have a significantly higher COE than amine scrubbing for a grass roots plant.

## CCPC Phase II

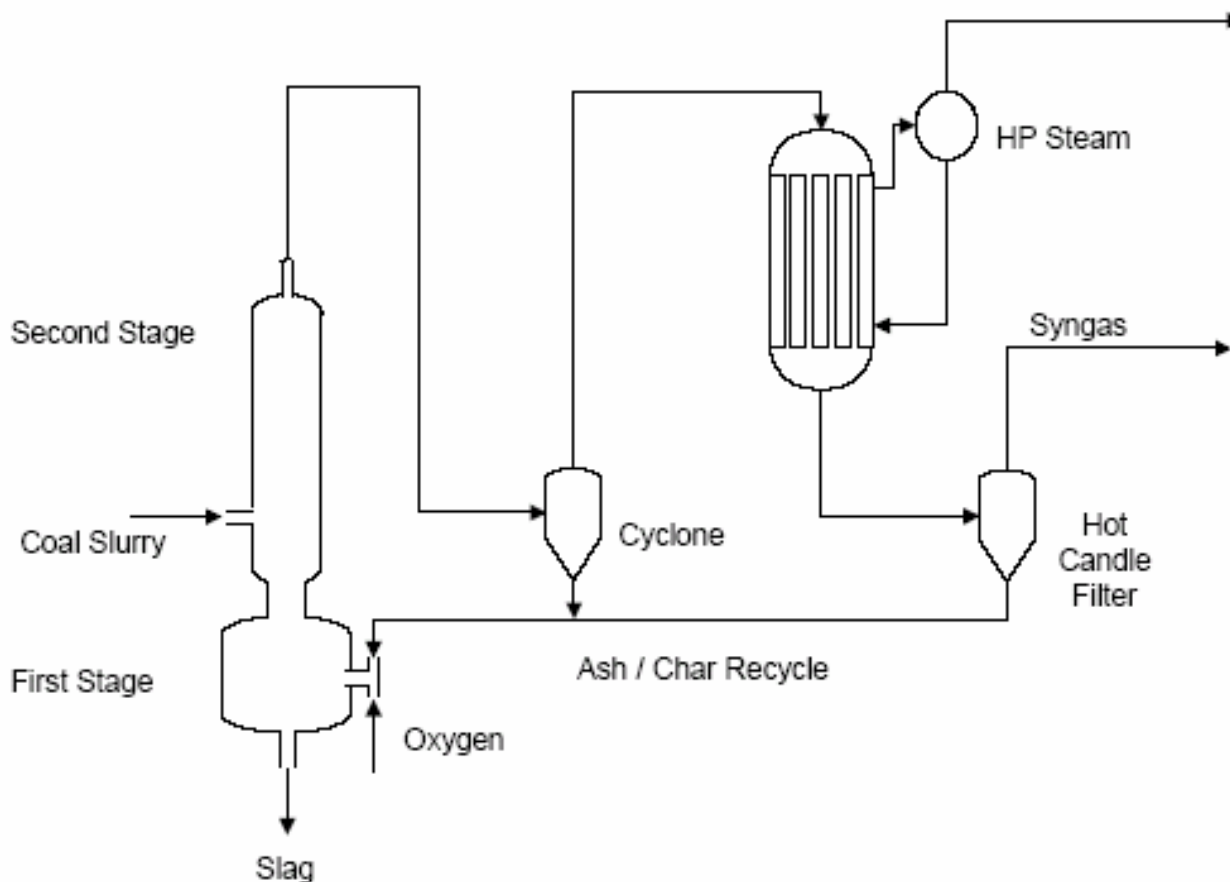
- Goal is to fill in technical uncertainties before moving to a firm project.
- Covers the following scope:
  - Gasification technology evaluation to develop better technology for low rank western Canadian coals.
  - Amine scrubbing & CO<sub>2</sub>/O<sub>2</sub> combustion optimization with advanced supercritical steam cycle.
- Upgrading of the coal prior to burning or gasification, by drying or blending with petroleum coke or other residues, will be evaluated.
- Business case development covering multiple cases:
  - Alberta: coal, bitumen and petcoke gasification
  - Saskatchewan: lignite and petcoke gasification
- Polygeneration of power, hydrogen, steam and CO<sub>2</sub> will be evaluated.

# Gasification Technologies Considered

- British Gas Lurgi
- *ConocoPhillips* \*
- EAGLE
- *Future Energy* \*
- GE Energy
- High Temperature Winkler
- Sasol-Lurgi
- Shell
- KBR Transport Gasifier

*\* Selected for development of performance and cost estimates*

# ConocoPhillips *Entrained Slagging Transport Reactor (ESTR)*



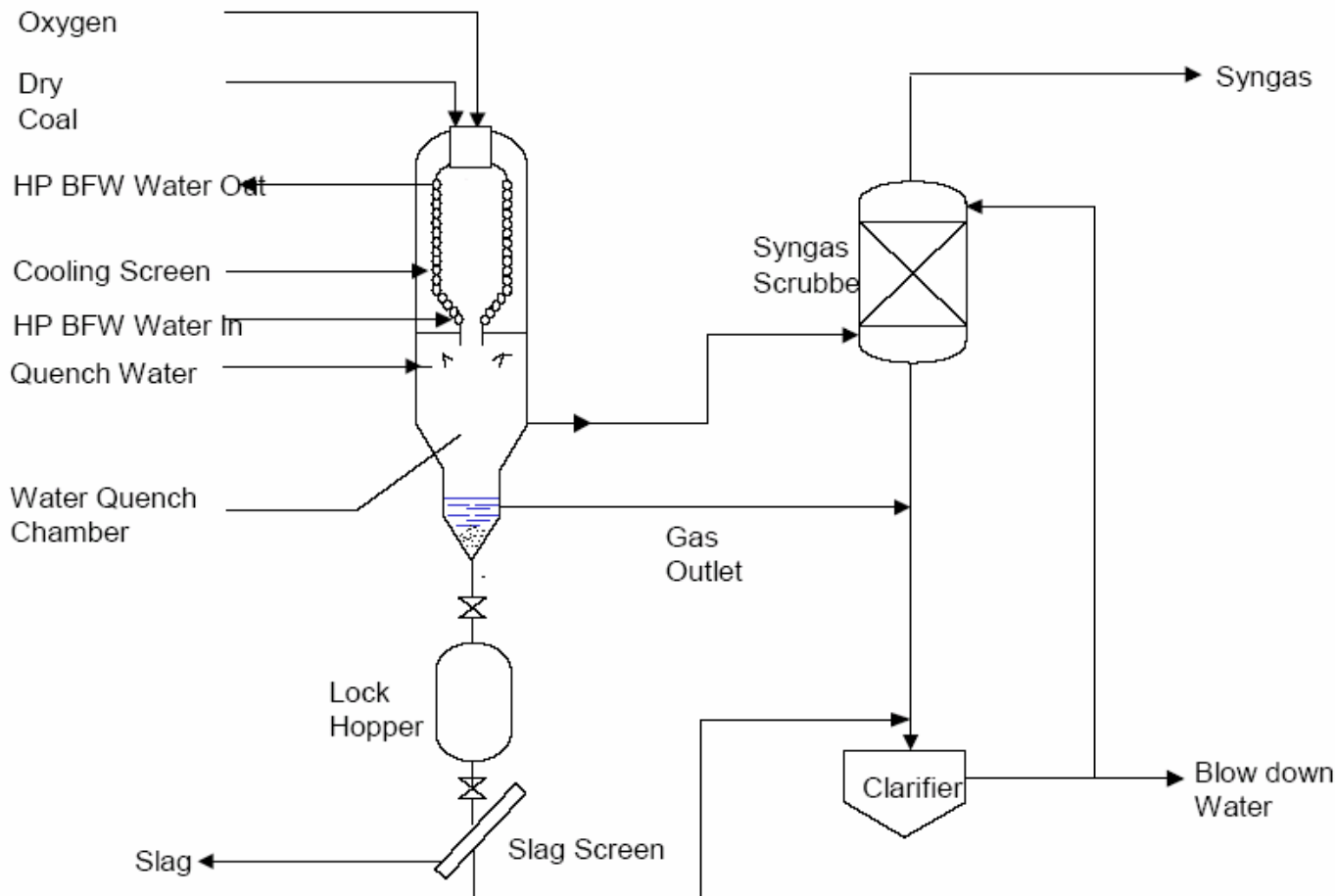
## Advantages

- Dry feed to 1<sup>st</sup> Stage
- High efficiency
- Slagging gasifier
- High pressure operation

## Disadvantages

- Refractory lined
- Higher methane content (*could limit CO<sub>2</sub> recovery*)
- No water quench

# Future Energy



## Advantages

- Dry feed
- Cooling screen
- Water quench
- Slagging gasifier

## Disadvantages

- Lack of operating experience at high pressure

## Preliminary Indications of Results

- IGCC with CO<sub>2</sub> capture on low grade coals improved by six percentage points (33% from 26%) for sub-bituminous coals and four percentage points (31% from 27%) for lignite coals (over Phase I results).
- Cost numbers still being finalized.

## Phase II Status - Advanced Supercritical Steam

- Advanced supercritical steam optimization studies will be done by Mitsui Babcock and Alstom, with support from the UK Government (DTI).
- The MHI advanced amine scrubbing system will be used for amine optimization studies.
- CO<sub>2</sub>/O<sub>2</sub> combustion optimization will be included, with support from Air Products.
- Studies on thermal integration to improve efficiency will be included in scope (Imperial College).
- Evaluating proposals for balance of plant sub-contractor.

# Summary of Phase II ASC Case Studies

- R0 Base Case Plant – an optimized air-fired ASC PC plant without CO<sub>2</sub> capture with appropriate emissions control, assume space is left to retrofit oxyfuel or post-combustion capture
- A1 Oxy-Combustion Capture Plant – an optimized oxygen-fired ASC PC boiler with oxyfuel CO<sub>2</sub> capture
- A2 Oxy-Combustion capture of base case plant – conversion of the base case R0 plant to CO<sub>2</sub> capture plus examination of pre-investment options
- B1 Post-combustion Capture Plant – an optimized air-fired ASC PC boiler with amine-based post-combustion CO<sub>2</sub> capture
- B2 Post-combustion capture of base case plant - conversion of the base case R0 plant to amine-based post-combustion CO<sub>2</sub> capture plus examination of pre-investment options

## Expected Phase II Outcomes

- Optimization of the 3 technology options for clean coal with CO<sub>2</sub> capture.
- Refine the capital and operating cost estimates, price of power and cost of CO<sub>2</sub> removal.
- Completion by Q3 2006.

## Conclusions

- Production of clean power with 90% CO<sub>2</sub> capture and removal of all emissions of concern is technically feasible and can become economically viable at certain locations
- Integrated gasification of low cost fuels (coal, coke) to co-produce power, hydrogen, heat and syngas (polygeneration) offers attractive commercial opportunities in Western Canada based on large markets for:
  - Hydrogen & heat for oil sands operations (replacing high cost natural gas)
  - Synthesis gas for chemical production
  - CO<sub>2</sub> for enhanced recovery of conventional oil (EOR) and for extraction of coal bed methane (ECBM). Excess CO<sub>2</sub> can be sequestered in deep aquifers
- Gasification costs and reliability depend on feed quality and there is little experience with low rank Western Canadian lignites, sub-bituminous coals and coal-coke mixtures

## Next Steps

- Some CCPC members have already taken the next steps to demonstration projects:
  - SaskPower's Clean Coal Project (2011)
  - Coal Beneficiation – Gasification Pilot Facility (2008/2009)
  - An application is in progress for front end engineering for an IGCC coal plant in Alberta (2015)

## NEB Scenarios

- First, a caveat – coal plants will typically have a life of 40 to 50 years
- TREEES
  - Clean coal technologies become the standard for new coal-fired power plants
  - Existing fleet replacement in the range of 2030 to 2050
- Fortified Islands
  - Slower economic growth will result in existing plants remaining in service longer
  - Deployment of clean coal technologies slows
- Continuing Trends
  - Strong economic growth will increase need for new power plants while the global market forces will encourage adoption of clean coal technologies

**Questions?**