PILOT TESTING OF WRI'S NOVEL MERCURY CONTROL TECHNOLOGY BY PRE-COMBUSTION THERMAL TREATMENT OF COAL

***Alan E. Bland**, Collin Greenwell and Jesse Newcomer - WRI*
Kumar Sellakumar – Etaa Energy
Barbara Carney – US DoE NETL

US DOE Mercury Control Conference

Pittsburgh, PA

December 13, 2007

Agenda

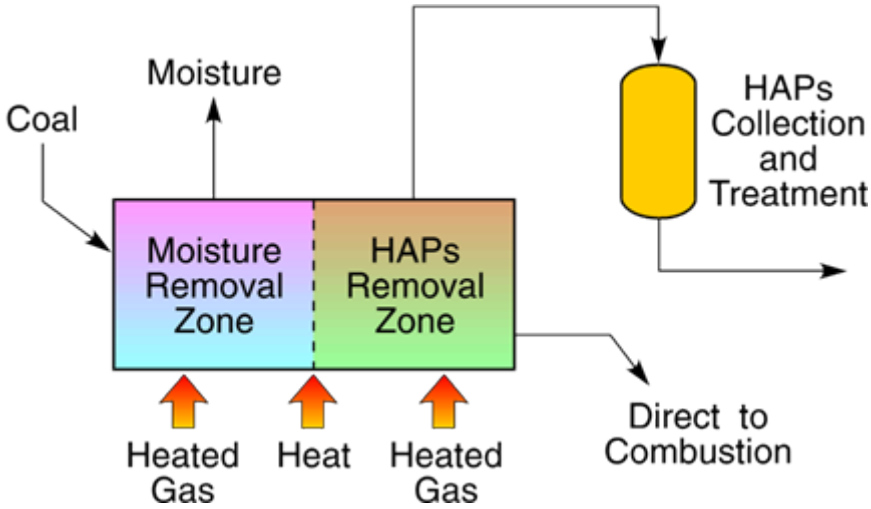
- Overview of WRI Mercury Removal Process
- Phase III Award Description
- Status of Progress
  - Coals Characterization
  - Bench-scale Testing
  - High Temperature Sorbent Testing
  - Pilot-scale Testing
- Questions

Disclaimer

This presentation was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed or represents that its use would not infringe on privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

WRI Pre-Combustion Thermal Mercury Removal Process

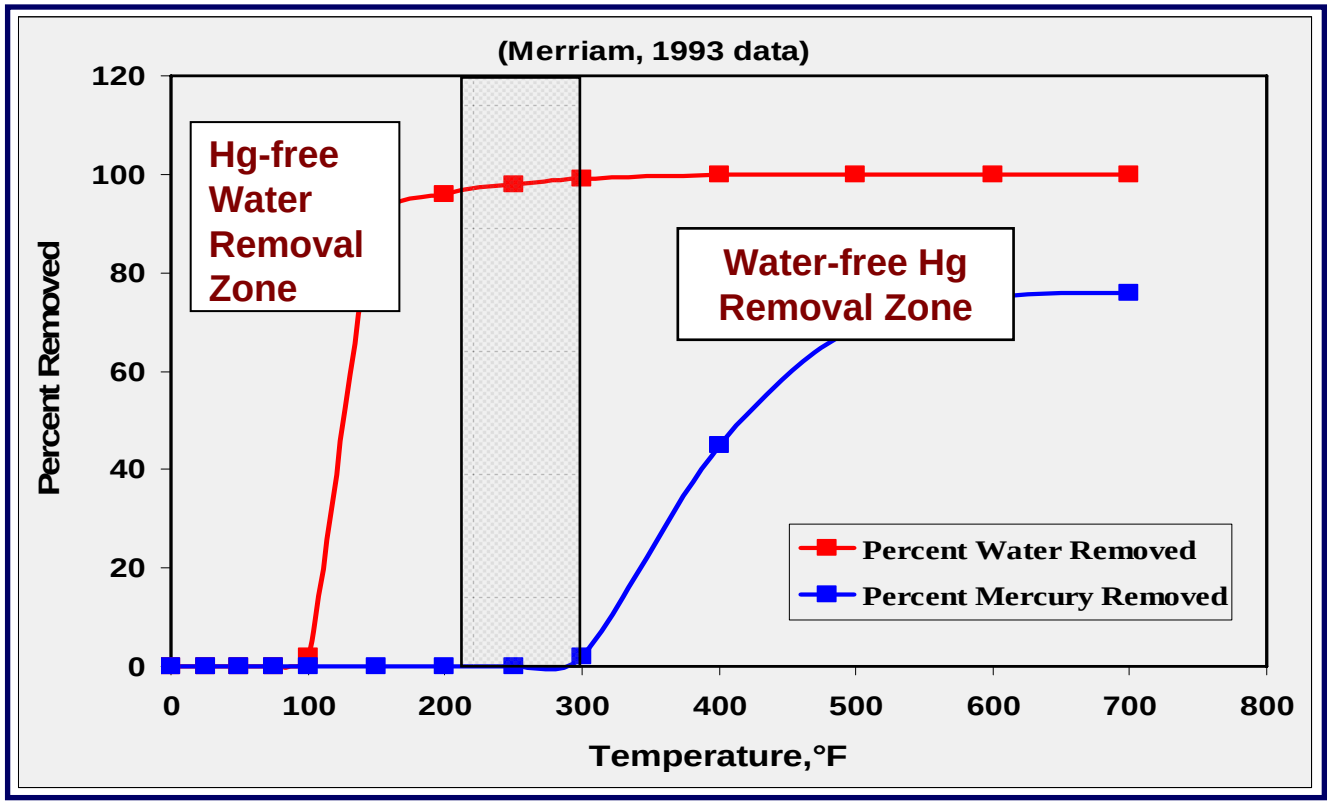
WRI's Patented Hg Removal Process



WRI was issued a patent (U. S. Patent No. 5,403,365) "*Process for Low Mercury Coal*" in 1995 based on a thermal treatment of the coal prior to combustion. (Follow-on patent is being prepared)

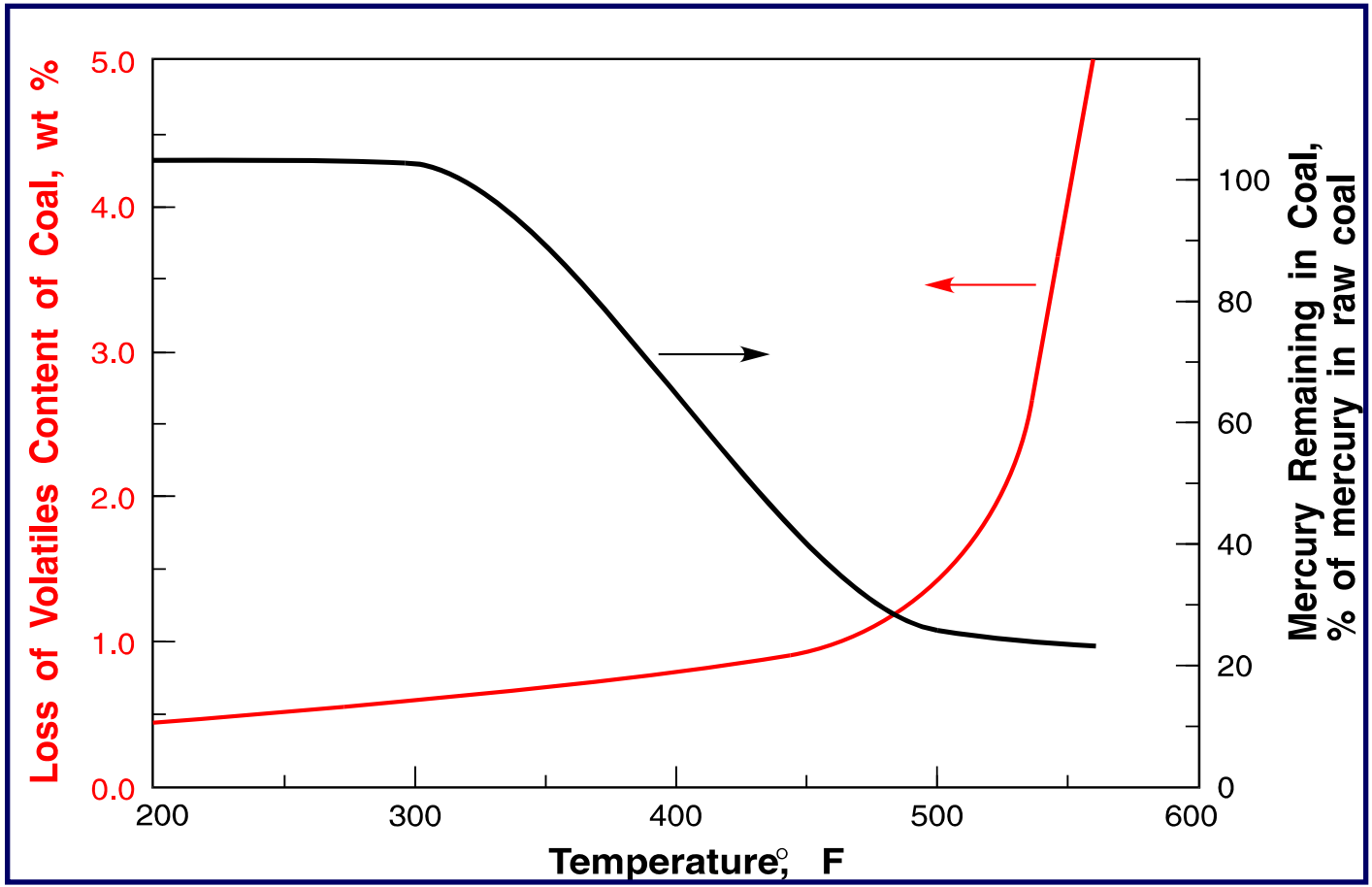
- ***Technology is applicable for low-rank coals both subbituminous (PRB) and lignite.***
- ***Process is currently envisioned as being deployable at the power plant.***

Removal of Water and Mercury



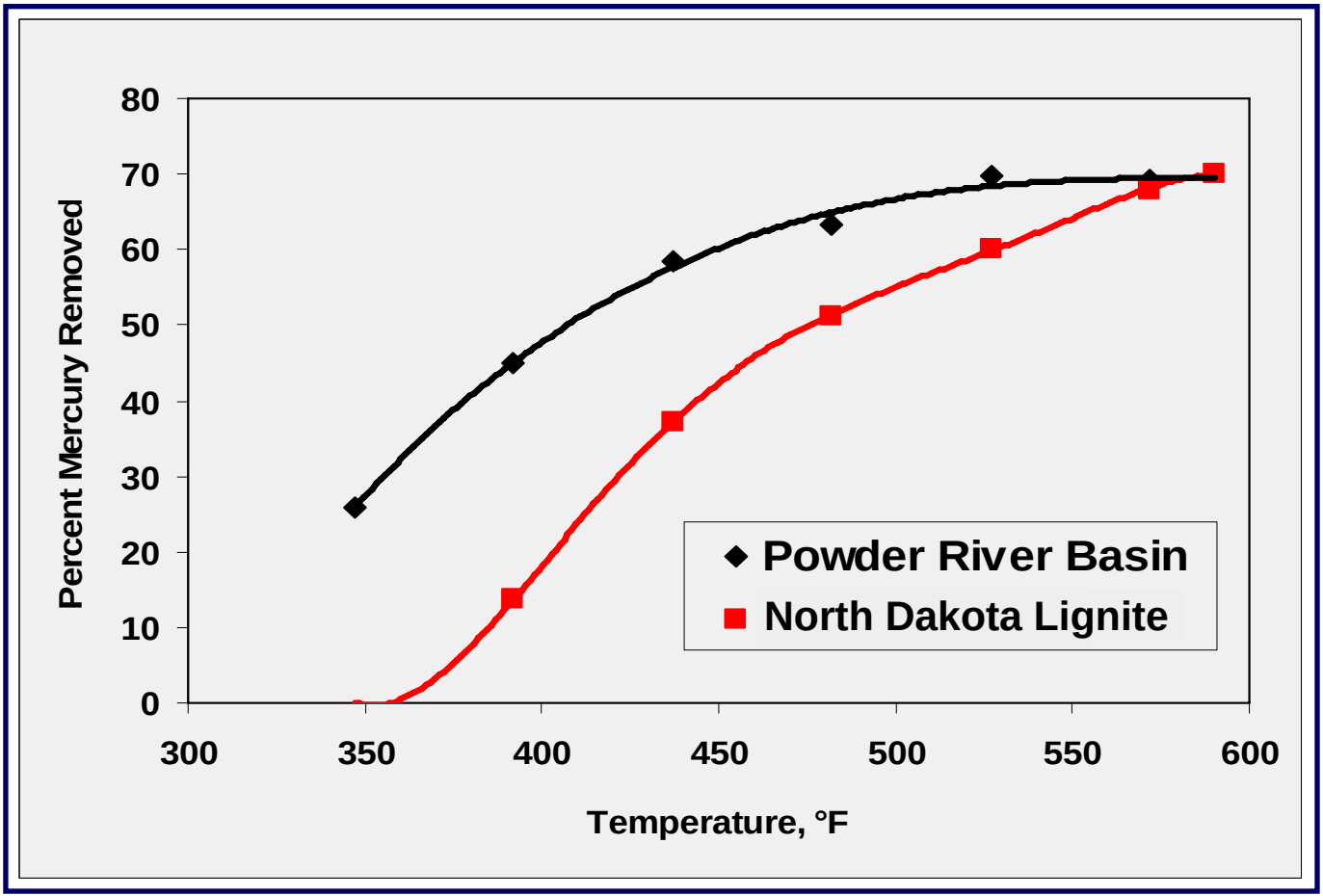
- *Two steps help drying and heating the coal to release mercury effectively.*

Removal of Mercury and Volatiles

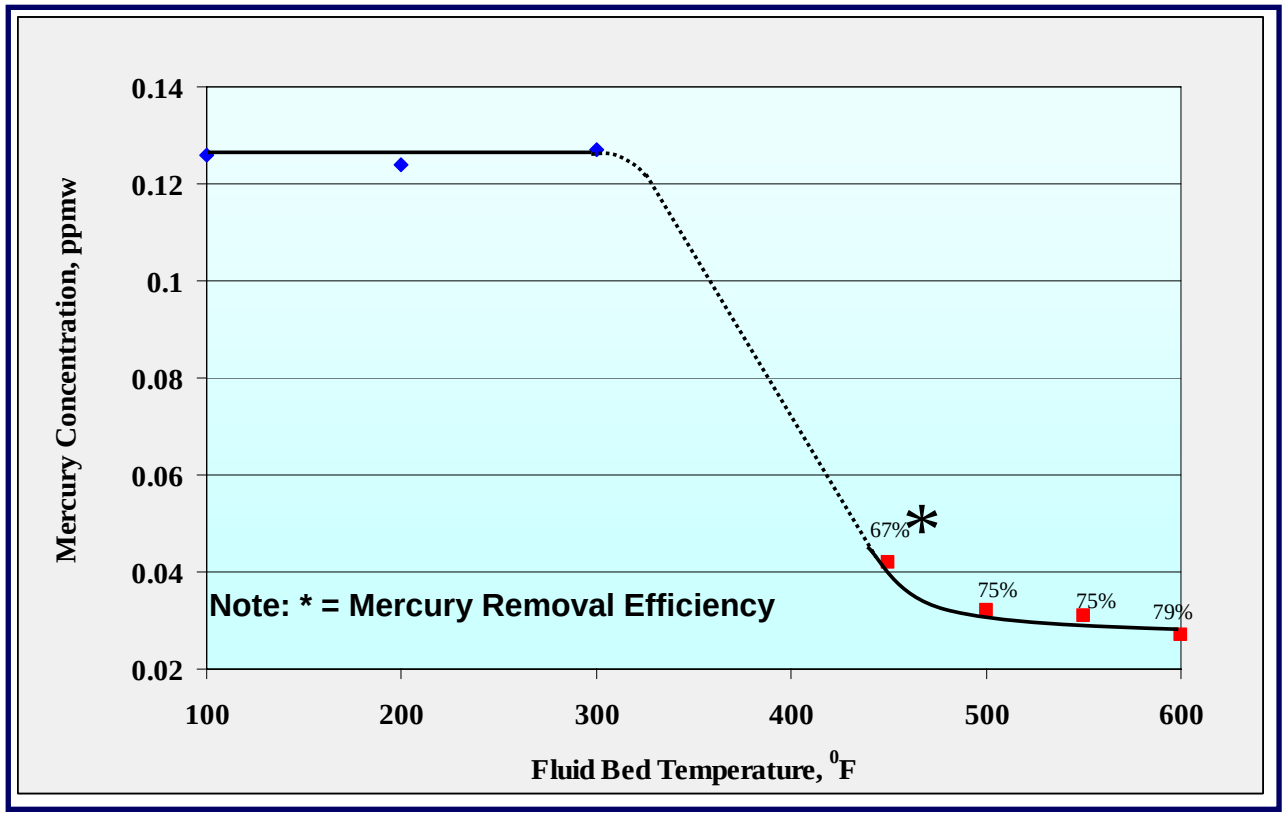


Process Results and Benefits

Typical Mercury Removal



Effect of Process Temp. on Hg Release



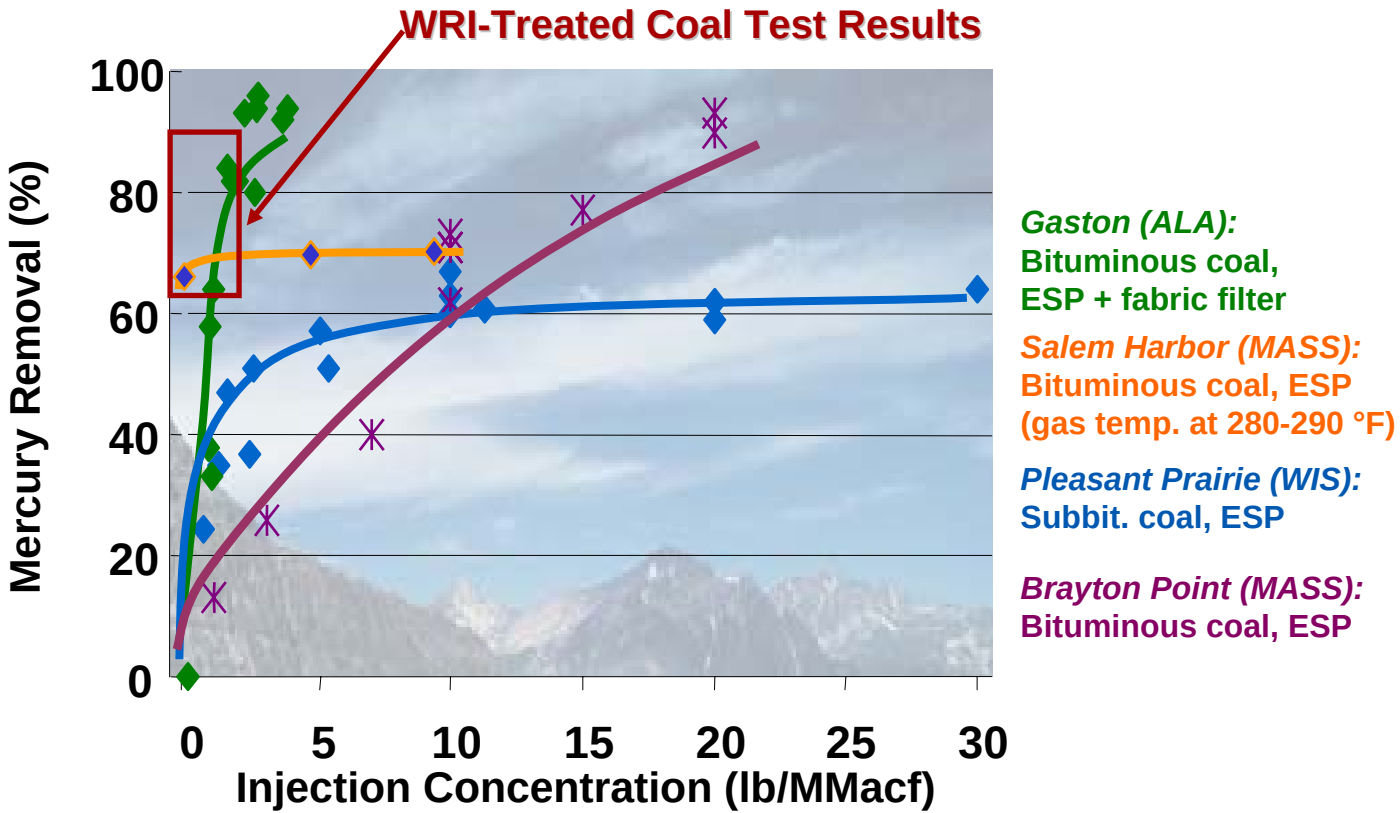
- *About 75 to 80% of mercury is released from the PRB coal at 550-575ºF.*

Forms of Mercury

Ontario Hydro testing was conducted to determine the species of the mercury evolved in the WRI process

- ***Approximately 98.5% of the mercury evolved in the WRI process is elemental***

WRI-Treated Coal Combustion Results



Gaston (ALA):
Bituminous coal, ESP + fabric filter

Salem Harbor (MASS):
Bituminous coal, ESP (gas temp. at 280-290 °F)

Pleasant Prairie (WIS):
Subbit. coal, ESP

Brayton Point (MASS):
Bituminous coal, ESP

Ref: WRI data added to ADA Data- Feeley, SEC Presentation, March 30, 2004

➢ ***Combined with low ACI rates, the process yields 64-93% removal of mercury.***

Cost of Hg Control*

Coal Type	Analysis Basis	% Reduction with WRI Technology
PRB Subbituminous	WRI Processed PRB	16.13
	Base Case (TOXECON)	
ND Lignite	WRI Processed Lignite	27.5
	Base Case (TOXECON)	

* Study by Electric Power Research Institute/ Washington Group International.

Assumptions:

- 500 MWe size power plant
- TOXECON-EPRI mercury control technology employing ACI into ESP with a FF

Benefits of WRI Process

- During the thermal treatment, other species including arsenic and selenium can be released and captured.
- Moisture reduction enhances plant efficiency and reduces auxiliary power consumption.
- Moisture can be harvested and made available for plant use.
- Combustion of treated coal showed reduced NOx emissions and higher oxidized mercury, allowing for greater native capture by the APCD.
- Estimates show the WRI process to cost less than some post-combustion Hg removal processes, even without considering the auxiliary cost benefits

DOE Phase III Award

WRI's DOE Hg Phase III Selection

"Pilot Testing of WRI's Novel Mercury Control Technology by Pre-Combustion Thermal Treatment of Coal"

- ✓ **Phase III proposal selected in February 2006; Contract signed Dec of 2006; full funding available April 20, 2007.**
- ✓ **Only pre-combustion (Area 4) proposal selected**

Solicitation Goals

- ✓ **>50% removal by pre-combustion**
- ✓ **>90% reduction in mercury when combined with removal during combustion and/or with ACI addition**
- ✓ **< $30,000/lb Hg removed**

WRI's DoE Hg Phase III Selection

Participants (6)

- Western Research Institute
- Etaa Energy
- Energy and Environmental Research Center
- Foster Wheeler North America
- GCEE (sorbent developer)
- Washington Group International

Sponsors (10)

- Electric Power Research Institute
- Southern Company
- Detroit Edison
- North Dakota Industrial Commission
- Etaa Energy
- Montana-Dakota Utilities
- Basin Electric Power Coop.
- SaskPower
- Foster Wheeler North America Corp.
- US DOE NETL

Phase III Scope of Work

Areas addressed:

- Validate a range of PRB and lignite coals that can be treated by the process through bench- and pilot-scale testing (WRI/Etaa)
- Validate high temperature sorbents for mercury removal (WRI/GCEE)
- Validate the earlier combustion results with a wider range of treated coals (WRI/EERC/Etaa)
- Integration of the technology at power plants for lignite and PRB coals (WRI/Foster Wheeler/Etaa)
- Assess the economics of the WRI pre-combustion thermal treatment process (WRI/Washington Group/Etaa)

➢ **Excellent team to develop and deploy the technology on a commercial scale**

Characterization of Project Coals

Project Coals

Eight Low-Ranked Coals of Varying Composition

Three Subbituminous (PRB) Coals

- **Northern PRB Region**
- **Eastern PRB Region**
- **Southern PRB Region**

Four Lignite Coals

- **Two Fort Union North Dakota Lignites**
- **Fort Union Canadian Lignite**
- **Gulf Coast Lignite**

One Western Bituminous Coal

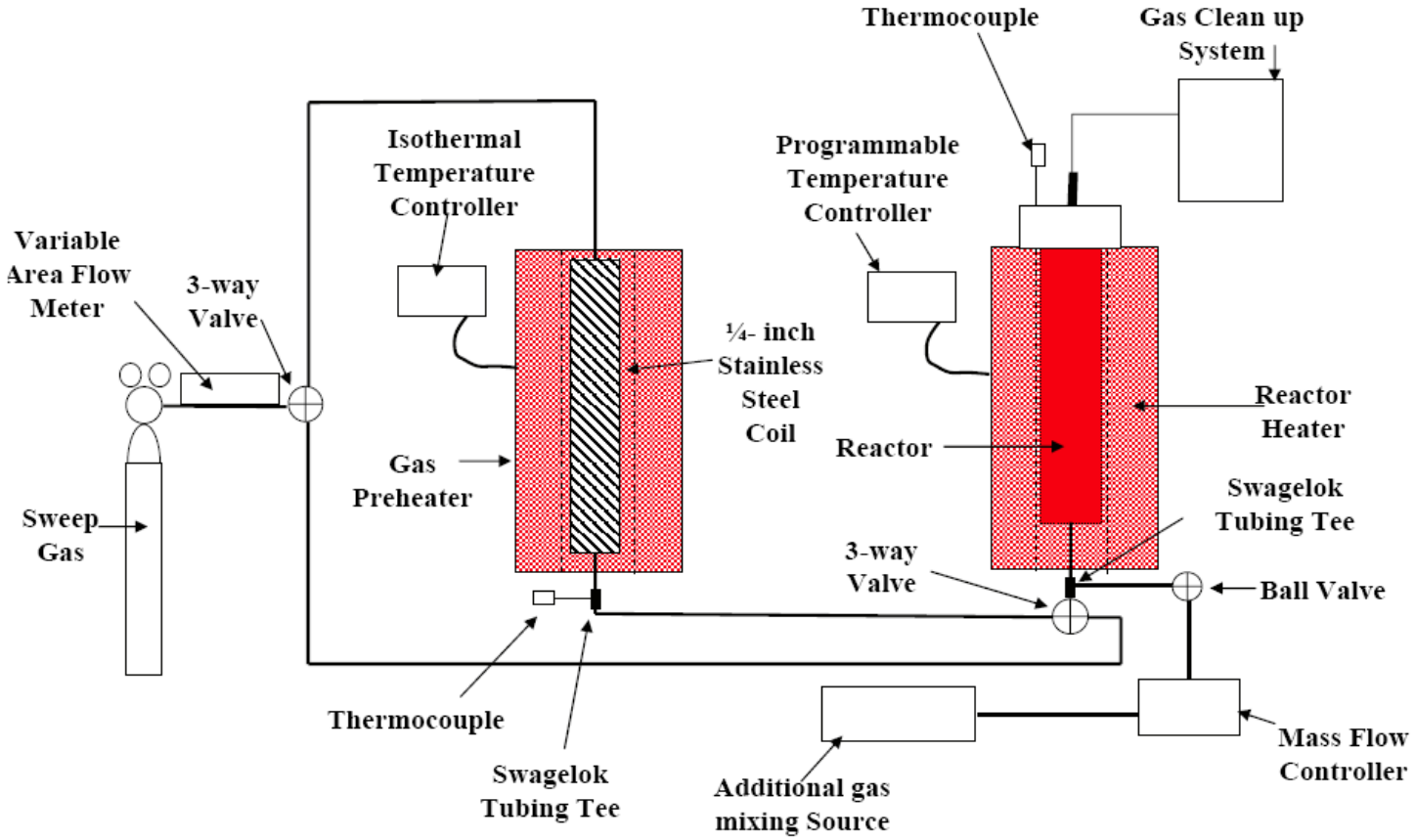
Coal Characterization Data

	Gulf Coast	Fort Union			PRB			Western Colorado [1]
Coal Rank	Lignite	Lignite	Lignite	Lignite	Subbit.	Subbit.	Subbit.	Bit.
Mercury, ppm,d	0.266	0.149	0.179	0.184	0.068	0.126	0.045	0.023
Moisture, % by wt.	20.91	36.39	34.68	36.55	30.01	28.36	22.40	16.24

1. Estimate from literature

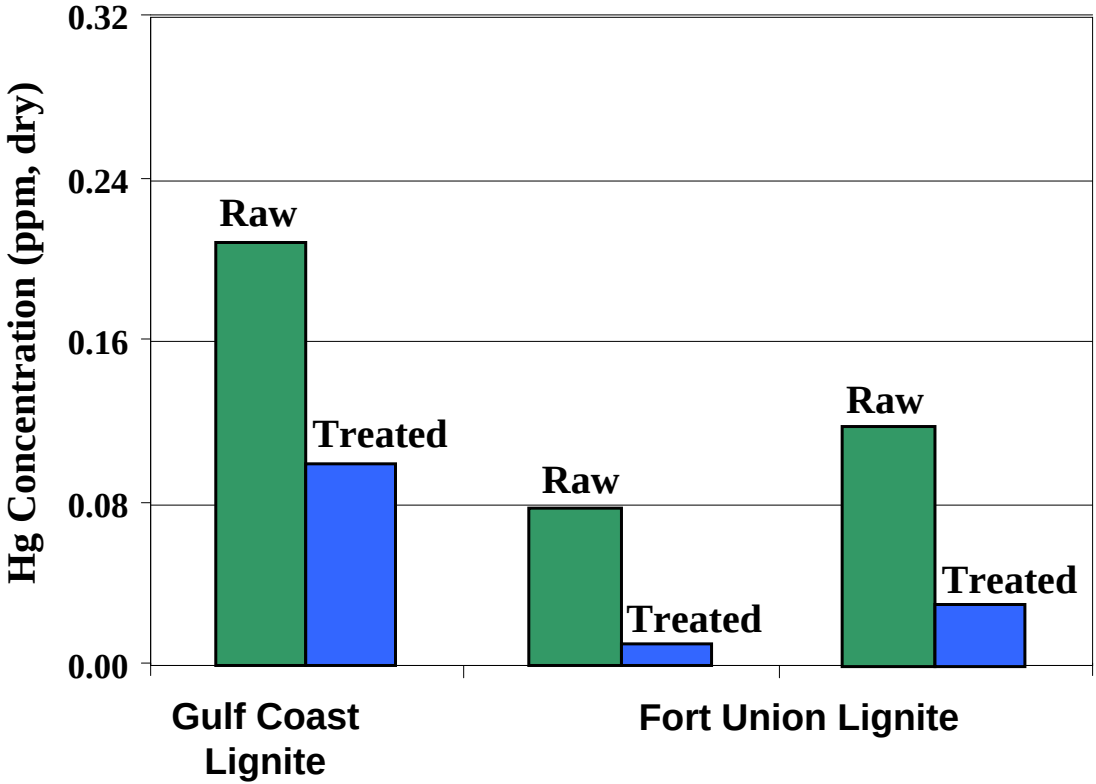
Bench-Scale Testing

Bench-Scale Testing Schematic



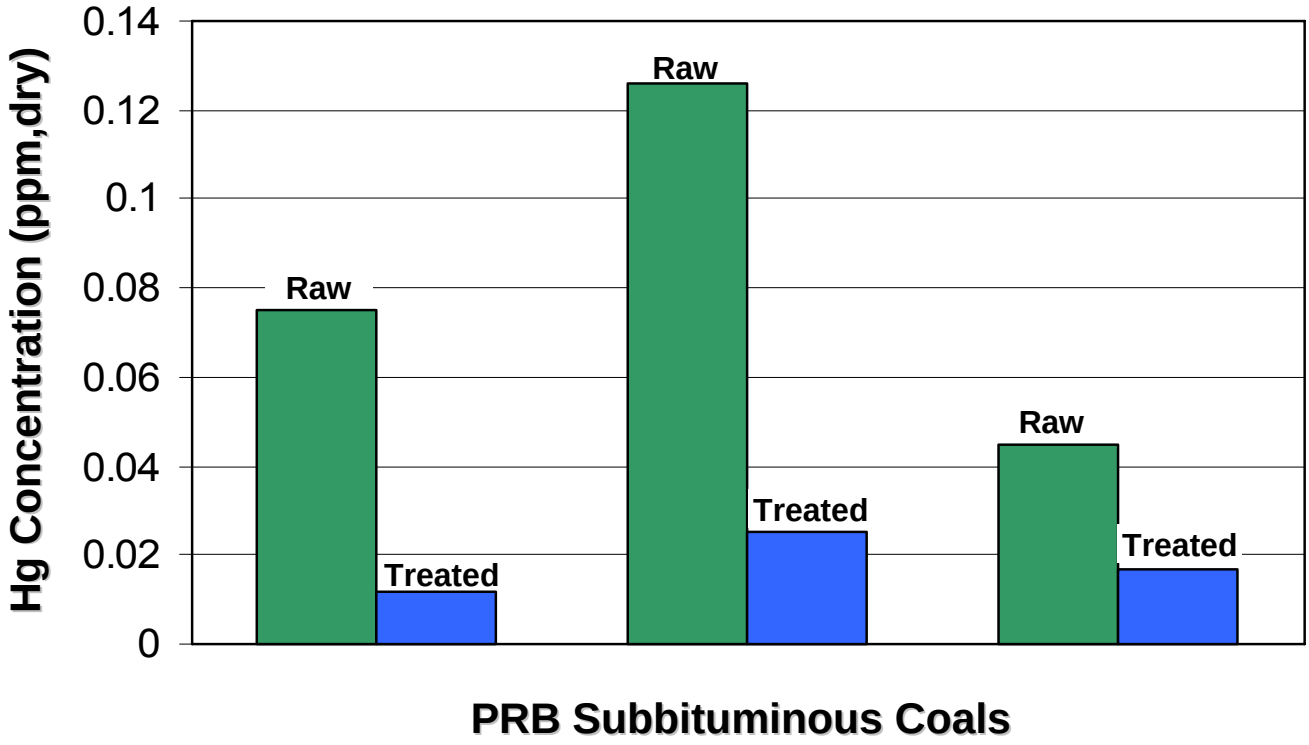
Bench-Scale Testing

Bench-Scale Testing



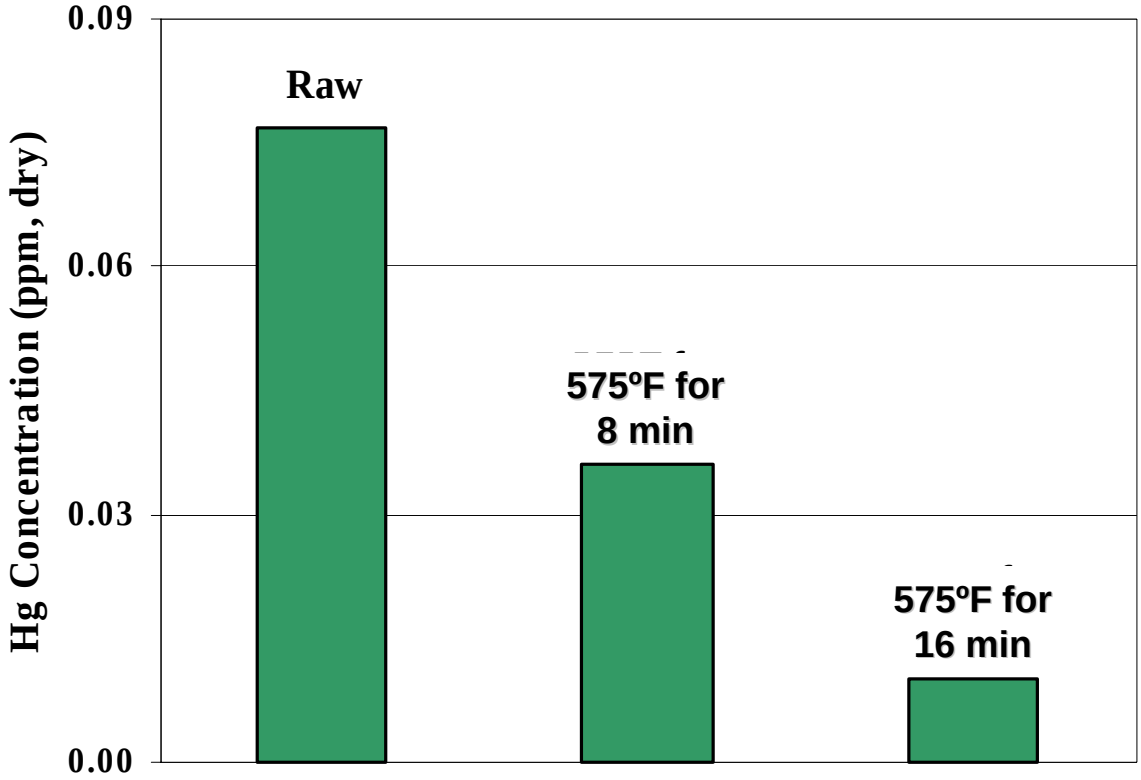
- **Preliminary lignite data shows Hg removal is significant**

Bench-Scale Testing



- **Preliminary PRB data shows Hg removal is significant**

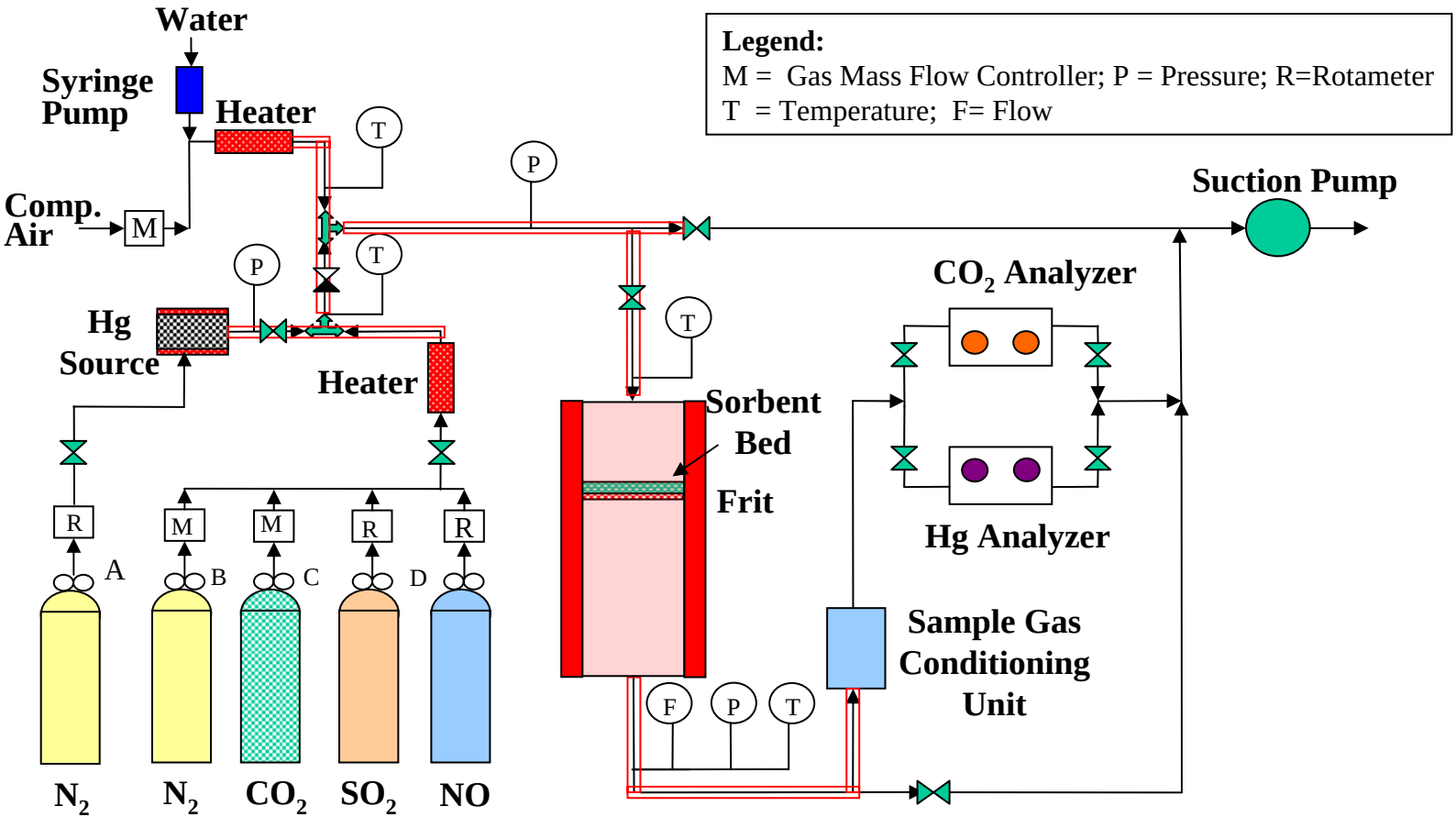
Bench-Scale Testing



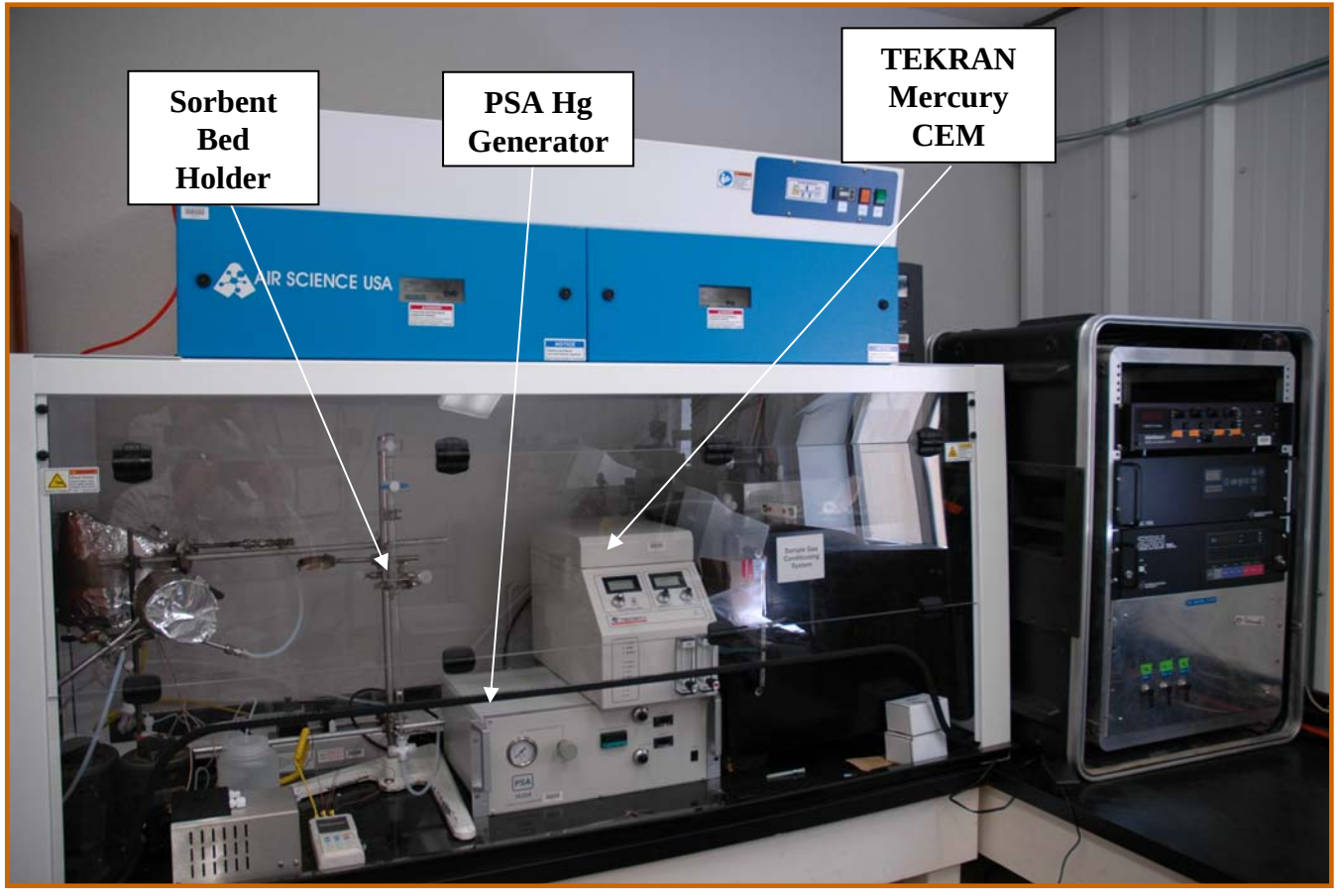
- **Residence time is a key parameter in mercury release**

High Temperature Sorbent Testing

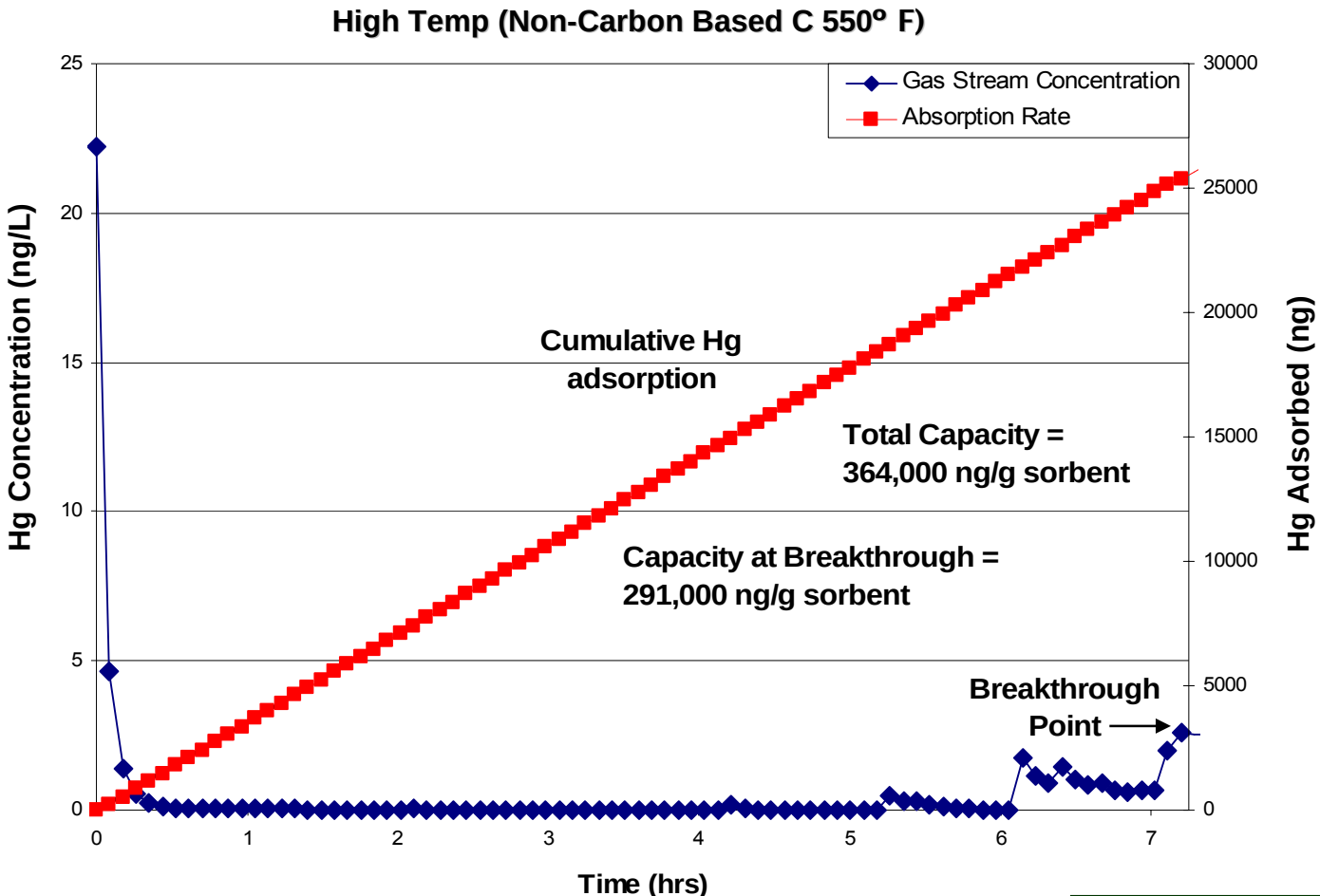
HT Sorbent Test Facility Schematic



HT Sorbent Testing



HT Sorbent Testing



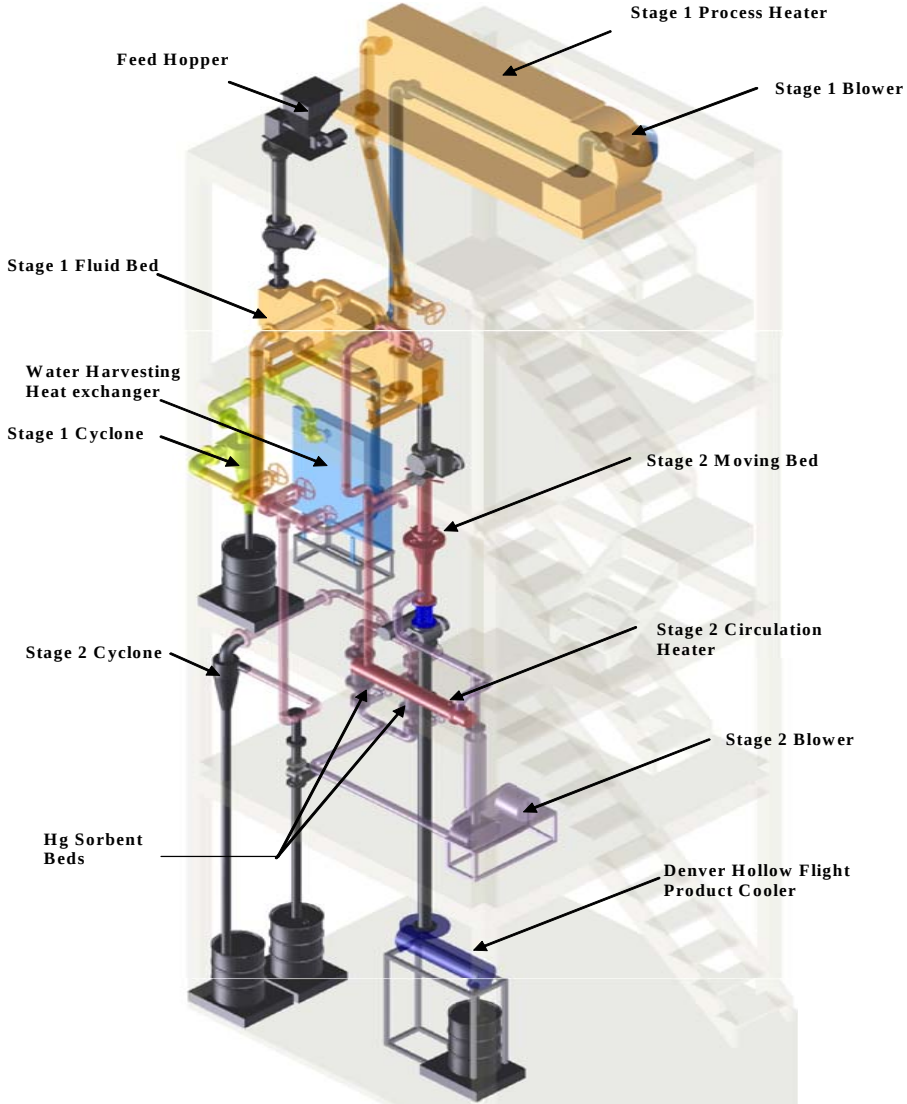
Typical HT Sorbent Loadings

Sorbent Type	Temp (°C)	Loading (μg Hg/ gm sorbent)
Activated Carbon	154	298
	300	130
Chemically Enhanced AC	300	NA
HT Sorbent – Carbon Based*	300	65 - 100
HT Sorbent – Non-Carbon Based*	300	300 - 500

* Proprietary sorbents supplied by various vendors

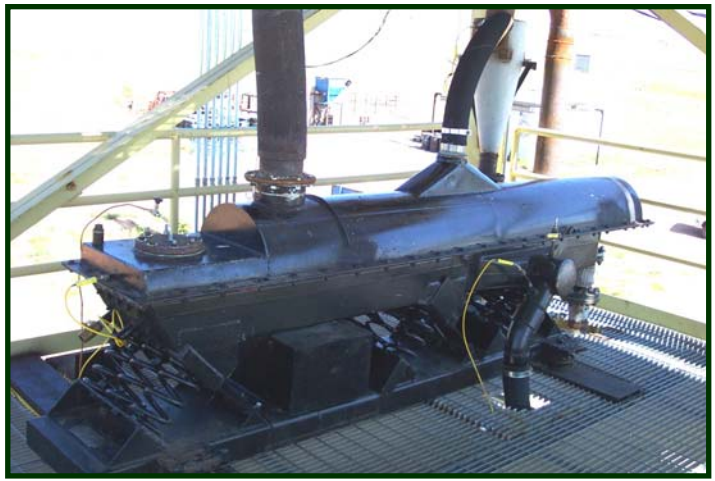
Pilot-Scale Mercury Removal Testing

Pilot-Unit Schematic



WRI Pilot-Scale Unit

Pilot Unit Equipment

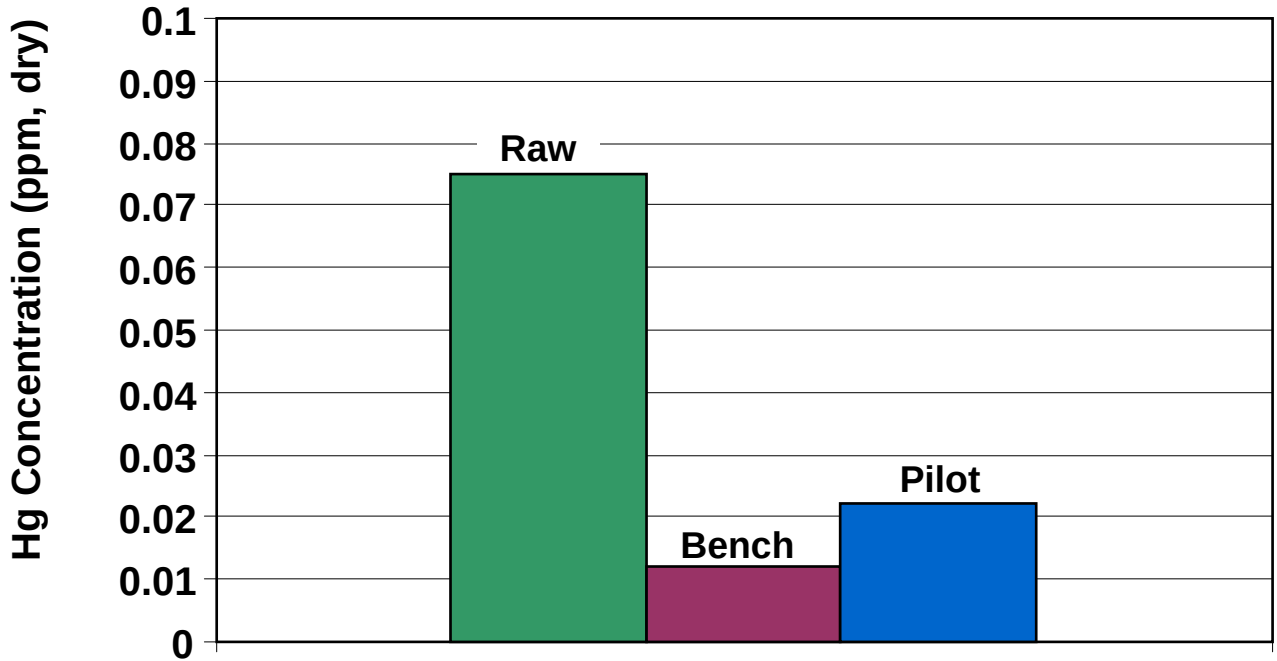


Pilot Unit Equipment

- **Treated coal cooler to be installed**

Installation of Condensing Heat Exchanger

Pilot-Scale Hg Removal



- **Preliminary pilot data during commissioning runs confirm bench-scale findings**

Phase III Scope of Work

Areas addressed:

- ✓ Validate a range of PRB and lignite coals that can be treated by the process through bench- and demonstration-scale testing (WRI/Etaa)
- ✓ Validate high temperature sorbents for mercury removal (WRI/GCEE)
- ❖ Validate the earlier combustion results with a wider range of treated coals (WRI/EERC/Etaa)
- ❖ Integration of the technology at power plants for lignite and PRB coals (WRI/Foster Wheeler/Etaa)
- ❖ Assess the economics of the WRI pre-combustion thermal treatment process (WRI/Washington Group/Etaa)

Summary

- **WRI's Pre-Combustion Thermal Mercury Control Process is a Unique Alternative to Post-Combustion Technologies.**
- **Process Applicable for a Wide Range of Low-Rank Coals.**
- **Process Improvements Through High-Temperature Sorbents Appear Feasible.**
- **WRI Process is Cost Competitive**
- **Process Benefits (e.g., Plant Efficiency Gains and Water Production) Make the WRI Process Uniquely Attractive for Many Utilities.**

Acknowledgements

Special thanks to the following and utilities and companies/organizations for their financial participation and support:

Basin Electric Power Cooperative
Detroit Edison
Electric Power Research Institute
Etaa Energy
Foster Wheeler North America
GCEE
Montana-Dakota Utilities
North Dakota Industrial Commission
SaskPower
Southern Company
U.S DOE NETL and Barbara Carney, COTR
DE-FC26-07NT42785

For More Information, Contact:

Alan E. Bland
Western Research Institute
365 North 9th Street
Laramie, WY 82072
(307) 721-2386
abland@uwyo.edu