



**NETL/DOE  
Mercury Control  
Technology R&D Program  
Review**

**Mercury Removal Results from  
Two Coal-fired Utility Boilers  
July 14, 2004**

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**We make coal **green.**<sup>®</sup>**



# Acknowledgements



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# Project Goals and Objectives



The principal goal of the two testing trials was to evaluate the overall effectiveness of EnviroScrub's Pahlman™ Process Technology on live flue gas streams from Utility boilers. Specific program objectives included the following:

- Verify and document Pahlmanite™ Sorbent's ability to remove both oxidized ( $\text{Hg}^{2+}$ ) and elemental ( $\text{Hg}^0$ ) mercury.
- Multi-pollutant ( $\text{NO}_x$ ,  $\text{SO}_2$ , Hg) capture demonstration utilizing an oxides of manganese sorbent, termed Pahlmanite™ Sorbent.
- Evaluate the rate of  $\text{Hg}^{2+}$  and  $\text{Hg}^0$  capture relative to  $\text{NO}_x$  and  $\text{SO}_2$  capture and breakthrough.

# Site Specifications



## **DTE Energy River Rouge Unit 3 (290 MW):**

PRB/eastern bituminous blend (40:60 to 60:40)

Pulverized Coal Wall-Fired Boiler

Low NOx Burners

Low Sulfur coal

ESP Particulate Control

## **Minnesota Power Boswell Energy Center Unit 4 (570 MW):**

PRB subbituminous coal

Tangentially Fired Combustion Engineering Boiler

Boiler-Fired System Designed for NOx Control

Wet FGD for SO<sub>2</sub> and Particulate control

ESP configured on FGD re-heat bypass loop for Particulate Control

# Testing Locations and Configurations



- EnviroScrub's demonstration pilot unit was operated at DTE Energy's River Rouge Plant and Minnesota Power's Boswell Energy Center.
- A slipstream of approximately 1000 SCFM was pulled from the exhaust duct downstream of the facilities ESP and routed to the EnviroScrub Pilot unit for emissions removal. The "clean" exhaust gas was then routed back to the ESP duct.
- The EERC performed simultaneous inlet and outlet Mercury measurements with the ontario-hydro (OH) method and Hg-CEMS

# Experimental Sampling Approach

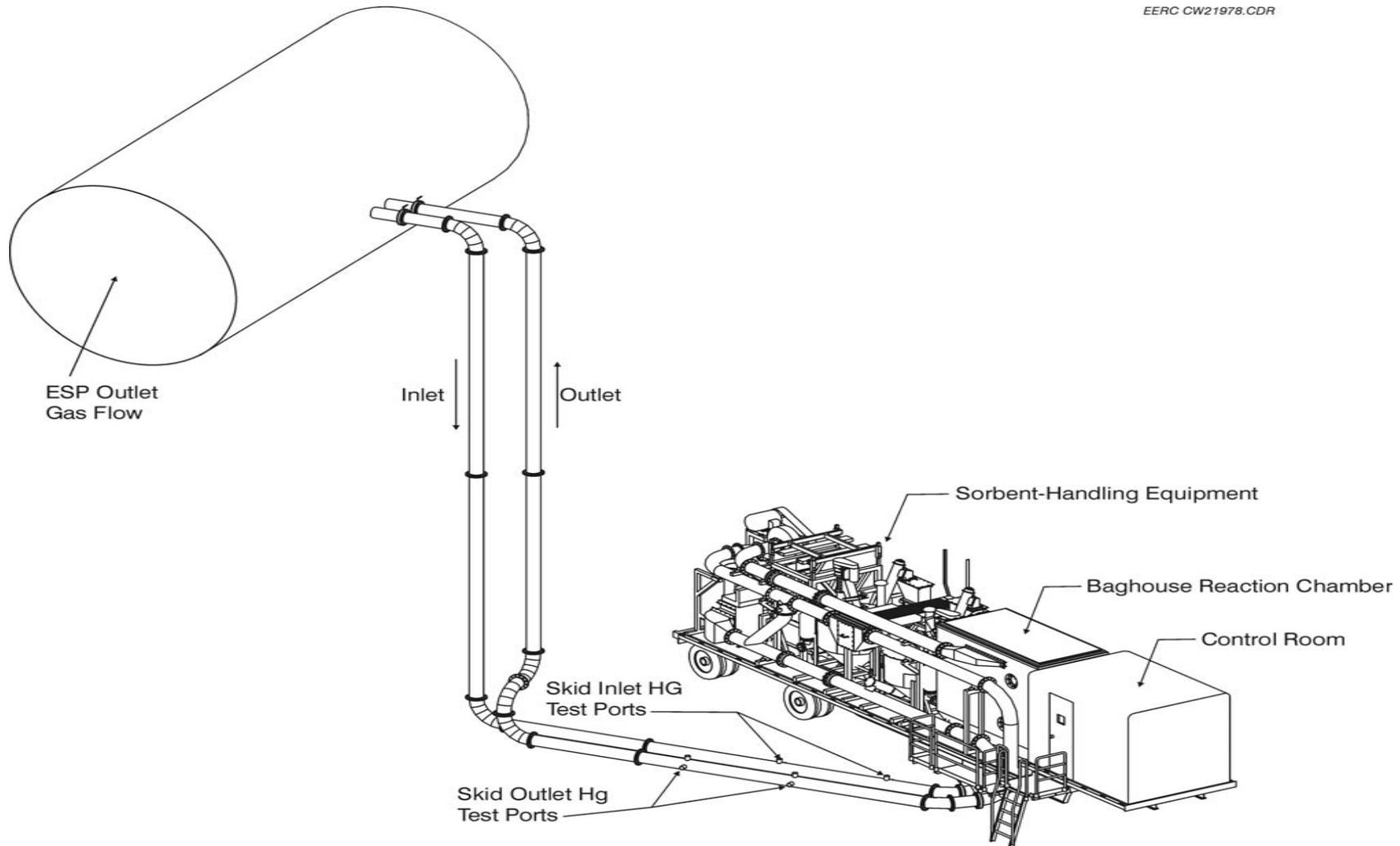


The Pilot Unit was brought up to temperature by circulating stack gas in the absence of sorbent. Once the Pilot Unit had reached operating temperatures, Pahlmanite™ Sorbent was loaded into the baghouse reaction chamber and testing commenced. During the testing period, inlet and outlet mercury measurements were conducted using both the EPA-approved Ontario Hydro (OH) test method as well as mercury semicontinuous emission monitors (Hg SCEMs). Additional flue gas monitoring as conducted using EnviroScrub's CEMs contained within the pilot unit. Concurrent with the mercury inlet and outlet test runs, concentrations of O<sub>2</sub>, NO<sub>x</sub>, SO<sub>2</sub>, CO<sub>2</sub>, and CO were measured. EnviroScrub's CEMs was configured and operated in accordance with EPA Code of Federal Regulations Part 60, Appendix A, Methods: 3A, 7E, 6C, and 10. Additional Pilot Unit parameters were monitored and recorded using the Pilot Unit's onboard PLC based data logging capabilities, such as: flue gas temperature and pressure, pilot unit flow rates, reaction chamber pressure drop, flue gas moisture, ect

# Pilot Scrubber Configuration



EERC CW21978.CDR



# Pilot Scrubber Configuration



**Minnesota Power's Boswell Energy Center**



# Pilot Scrubber Configuration



**DTE Energy's River Rouge Power Plant**

# Pilot Scrubber Test Results



## Summary of Third-Party Pilot Performance Testing

|           |                                |                                   |   | Average Steady State Removal Results                  |   |   |
|-----------|--------------------------------|-----------------------------------|---|---|---|---|
| Date      | Company/Site                   | Fuel Source                       | Testing Group   | * SO <sub>2</sub>                                     | * NO <sub>x</sub>                                     | Hg  |
| June 2003 | DTE Energy's River Rouge Plant | Blend: PRB and Eastern bituminous | Energy and Environmental Research Center (University N.D) | 99.8%<br>459 to 0.9 ppm<br>1.134 to 0.002<br>lb/MMBtu | 98.2%<br>150 to 2.7 ppm<br>0.266 to 0.005<br>lb/MMBtu | ** 97%<br>(oxidized)<br>1.02 to 0.03<br>μg/m <sup>3</sup> |

\* EERC Performed the Hg testing, while the NO<sub>x</sub> and SO<sub>2</sub> data was collected using EnviroScrub's CEMS

\*\* Run No 4 from EERC Test Report Contract No. NS-363299

# Pilot Scrubber Test Results



## Summary of Third-Party Pilot Performance Testing

|                      |   |             |  | Average Steady State Removal Results                |  |  |
|----------------------|---|-------------|--|---|--|--|
| Date                 | Company/Site                                  | Fuel Source | Testing Group  | * SO <sub>2</sub>                                   | * NO <sub>x</sub>                                    | Hg   |
| Dec-Jan<br>2003-2004 | Minnesota<br>Power's Boswell<br>Energy Center | Western PRB | Energy and<br>Environmental<br>Research Center<br>(University N.D) | 99%<br>480 to 4.6 ppm<br>1.054 to 0.012<br>lb/MMBtu | 95.8%<br>228 to 10 ppm<br>0.360 to 0.018<br>lb/MMBtu | 94.3% Total<br>99.2% Elemental<br>84.4% Oxidized |

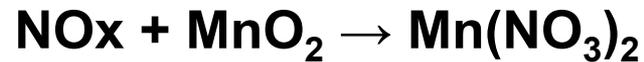
\* EERC Performed the Hg testing, while the NO<sub>x</sub> and SO<sub>2</sub> data was collected using EnviroScrub's CEMS

Full EERC Report to be released and will be made available at [www.envioscrub.com](http://www.envioscrub.com)

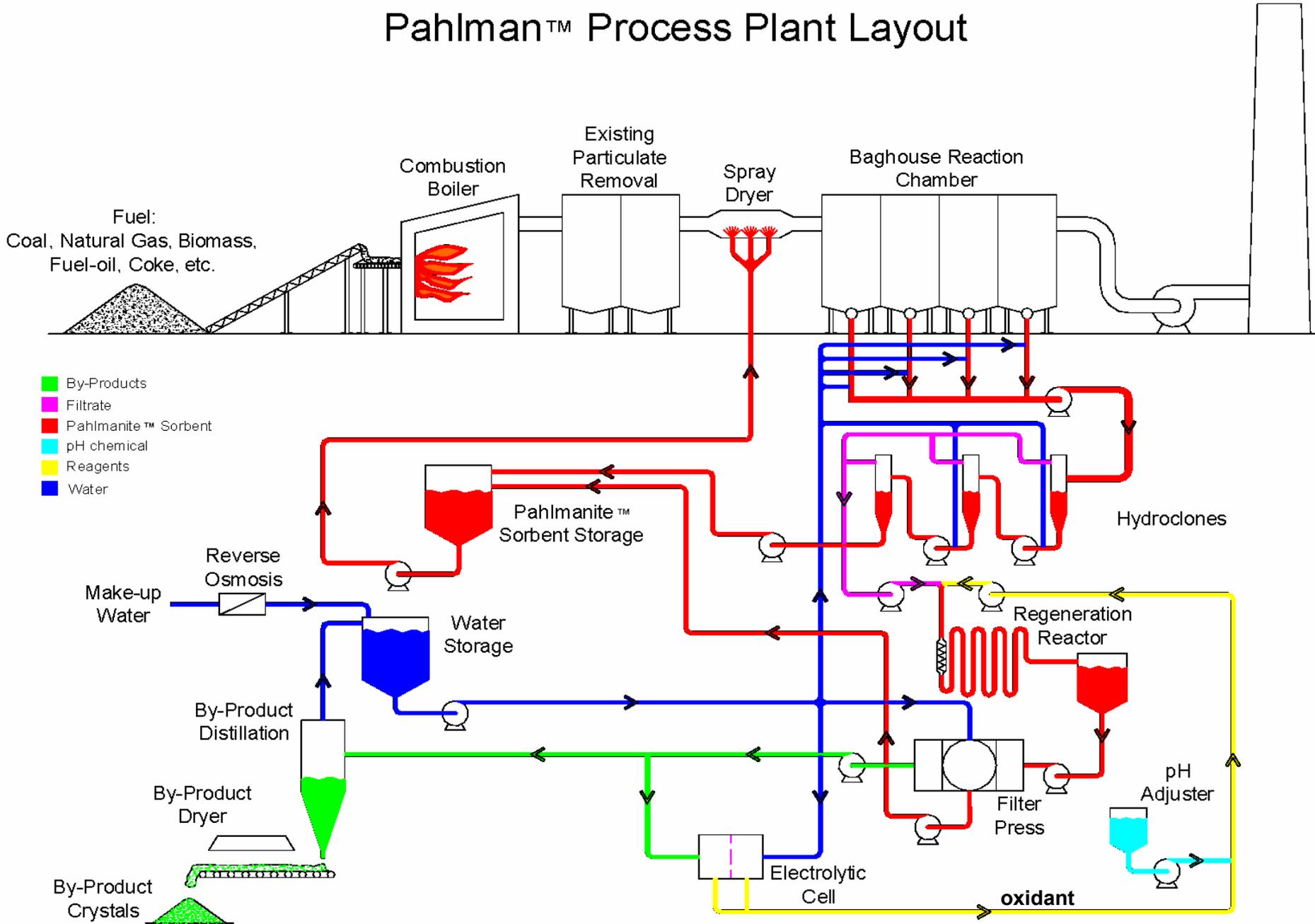
# Pollutant Capture Reactions



## Simplified Pollutant Capture Reactions



# Pahlman™ Process Plant Layout



# Pahlman™ Process Pricing Estimates



**Design Criteria**  
**NOx 95% and SOx 99% Removal Rates**  
**Total Mercury Removal Rate of 95%**

|  |               |               |
|--|---------------|---------------|
| <b>Plant Capacity (MW)</b>                   | <b>250</b>    | <b>500</b>    |
| <b>Coal Sulfur Content</b>                   | <b>0.7%</b>   | <b>0.7%</b>   |
| <b>NOx (lb/MMbtu)</b>                        | <b>0.4</b>    | <b>0.4</b>    |
| <b>Heat Rate (btu/kwh)</b>                   | <b>10,000</b> | <b>10,000</b> |
| <b>Plant efficiency</b>                      | <b>34.1%</b>  | <b>34.1%</b>  |
| <b>HHV (btu/lb)</b>                          | <b>10,000</b> | <b>10,000</b> |
| <b>Capital equipment costs (\$/kw)</b>       | <b>\$246</b>  | <b>\$184</b>  |
| <b>Operating expense (\$/mwh)</b>            | <b>\$0.84</b> | <b>\$0.63</b> |
| <b>Electric power required (MW)</b>          | <b>8.2</b>    | <b>16.3</b>   |
| <b>Thermal energy required (Mbtu/hr)</b>     | <b>160</b>    | <b>320</b>    |
| <b>Power required as % of plant capacity</b> | <b>3.3%</b>   | <b>3.3%</b>   |

Full Mercury Removal Test Reports and Additional  
Information is Available Upon Request

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