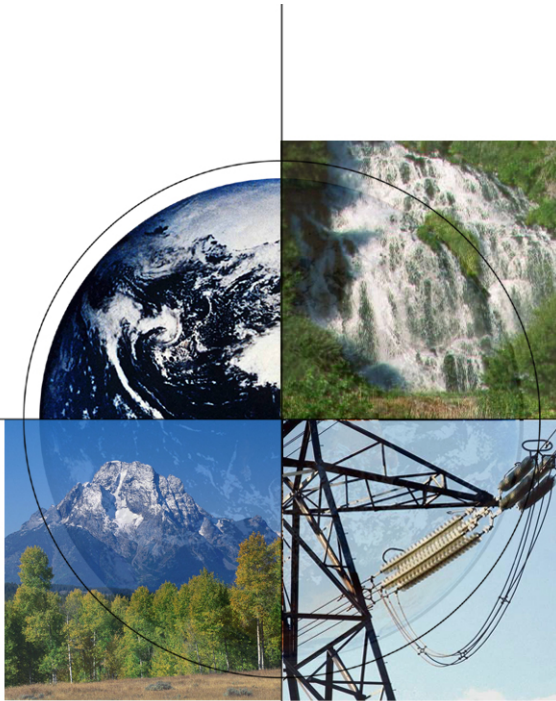


# An Update of DOE's Phase II Mercury Control Technology Field Testing Program

## *American Coal Council's 2005 Mercury & Multi- Emissions Conference*

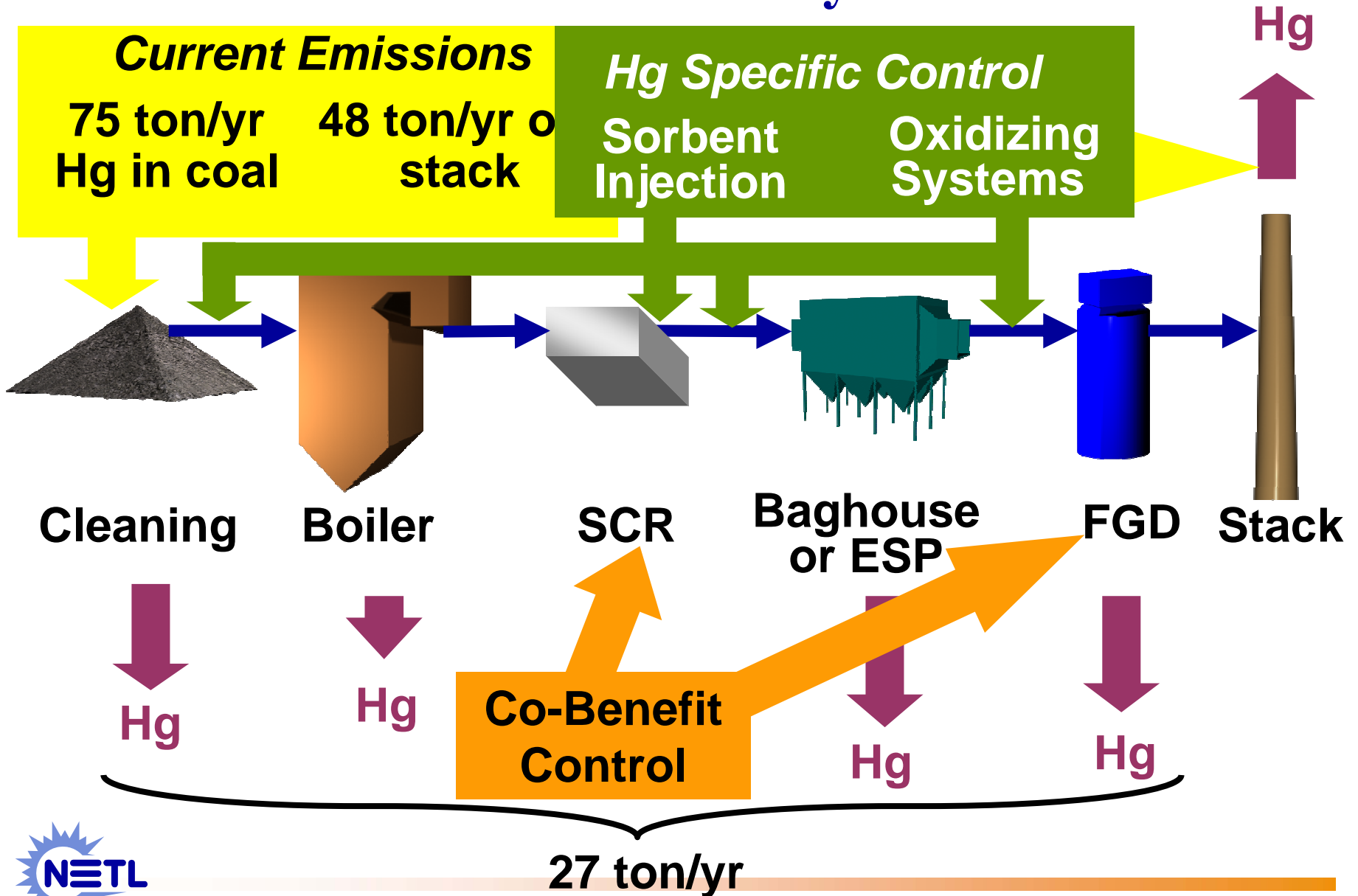
*March 22-24, 2005  
St. Louis, MO*



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National Energy Technology Laboratory



# Power Plant Mercury Control



# DOE Mercury Control RD&D Portfolio

## Boiler

- Combustion modification
- Chemistry modification

## FGD Enhancements

- Oxidation catalysts
- Reagent addition
- Ultraviolet radiation
- Electro catalytic oxidation
- SCR oxidation

## Coal Combustion Byproduct Characterization

## Polishing Technology

- MerCAP™

## Plume Chemistry

- Transport/  
speciation

## Sorbent Injection

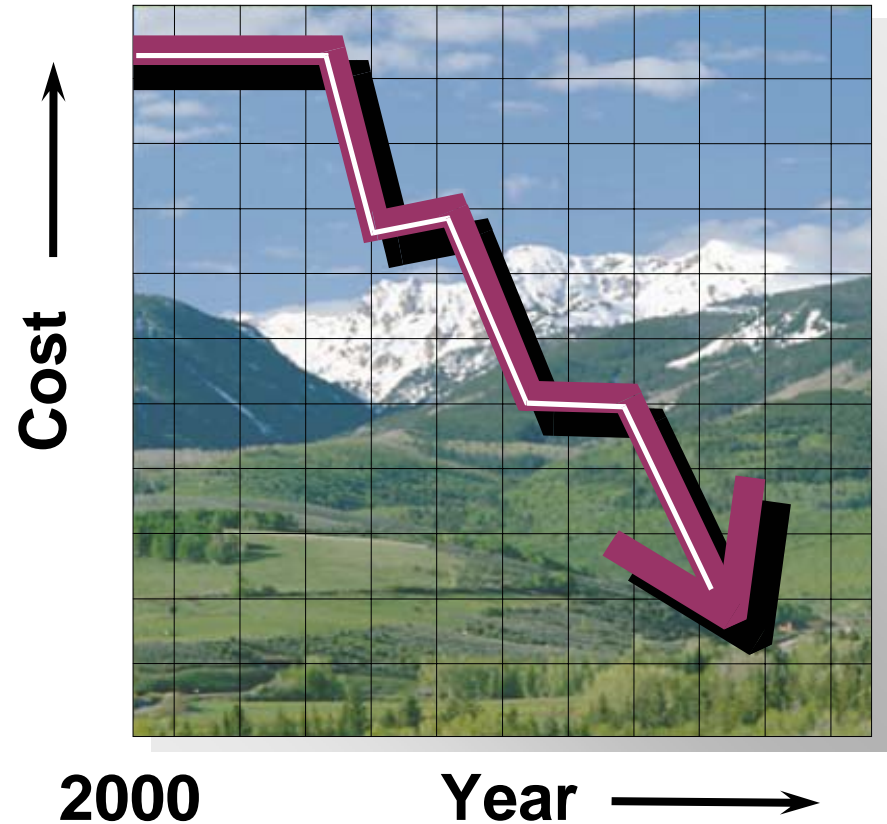
- Activated carbon
- Amended silicates
- Halogenated AC
- Ca-based sorbents
- Chemically treated sorbents
- COHPAC/Toxecon™
- Thief sorbents



# Mercury Field Testing Program

## *Phase II Objectives*

- Have technologies ready for commercial demonstration
  - by 2007 for all coals
- Reduce emissions 50-70%
- Reduce cost by 25-50% compared to baseline cost estimates



**Baseline Costs: \$50,000 - \$70,000 / lb Hg Removed**



# Phase I Field Testing 2001-2003 Summary

- **Activated carbon injection (ADA-ES)**
  - 4 power plant sites
    - 2 particulate collection systems --ESPs (3) and COHPAC (1)
    - 2 coal types – PRB (1) and bituminous (3)
- **Scrubber enhancement (McDermott/B&W)**
  - 2 power plant sites
    - Both burned high-S bituminous coal
    - 1 limestone wet FGD, 1 magnesium-enhanced wet FGD



# Phase II Mercury Control Field Test Projects

- Fourteen new projects selected
- Longer-term (1-6 months @ optimum conditions), large-scale field testing
- Broad range of coal-rank and air pollution control device configurations; focus on low-rank coals
- Sorbent injection & mercury oxidation control technologies

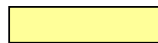


# DOE/NETL Phase II Mercury Control Field Testing Technology Matrix

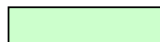
| Coal Rank                 | Cold-side ESP<br>(low SCA) | Cold-side ESP<br>(medium or high<br>SCA) | Hot-side ESP   | TOXECON      | ESP/FGD      | SDA/FF            |
|---------------------------|----------------------------|--|----------------|--------------|--------------|-------------------|
| Bituminous                | Miami Fort 6               | Lee                                      | Buck           | Independence | Yates 1      |                   |
|                           |                            | Buck                                     |                | Gavin        | Yates 1      |                   |
|                           | Yates 1&2                  | Portland                                 |                |              | Conesville   |                   |
|                           |                            | Sevier                                   |                |              | Conesville   |                   |
|                           |                            | Monroe                                   |                |              |              |                   |
| Subbituminous             | Crawford                   | Meramec                                  | Council Bluffs |              |              |                   |
|                           |                            | Dave Johnston                            | Louisa         |              |              |                   |
|                           |                            |  | Will County    |              |              |                   |
| Lignite (North<br>Dakota) |                            | Leland Olds 1                            |                |              | Milton Young | Antelope Valley 1 |
|                           |                            | Leland Olds 1                            |                |              |              | Stanton 10        |
|                           |                            | Stanton 1                                |                |              |              | Stanton 10        |
| Lignite (Texas)           |                            |  |                |              | Monticello   |                   |
|                           |                            |  |                |              | Monticello   |                   |
|                           |                            |  |                |              | Monticello   |                   |
| Blends                    |                            | St. Clair                                |                | Big Brown    |              | Holcomb           |



Sorbent Injection



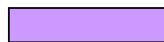
Sorbent Injection & Oxidation Additive



Oxidation Additive



Oxidation Catalyst



Chemically-treated sorbent

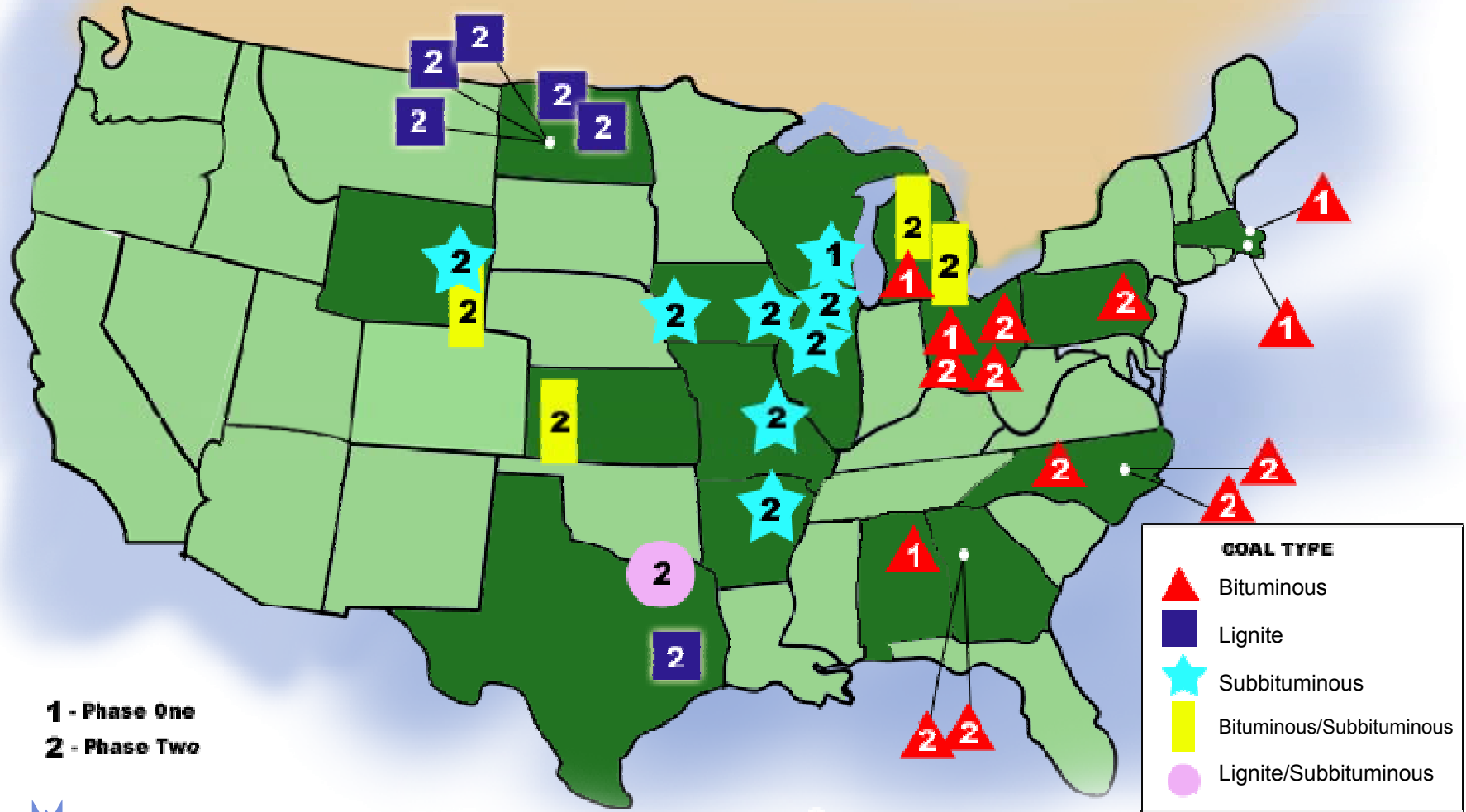


Other – MERCAP, FGD Additive, Combustion





# DOE/NETL Phase I & II Mercury Field Sites





# Evaluation of Sorbent Injection for Mercury Control

## *ADA-ES*

- Evaluate full-scale sorbent injection with existing pollution-control equipment at four sites:
- ***Sunflower Electric's Holcomb Station***
  - burns PRB/Bit coal blend and equipped with SDA/FF
- ***Detroit Edison's Monroe Station***
  - burns bituminous coal and equipped with ESP
- ***AmerenUE's Meramec Station***
  - burns PRB and equipped with ESP
- ***AEP's Conesville Station***
  - burns bituminous coal and equipped with ESP and wet FGD

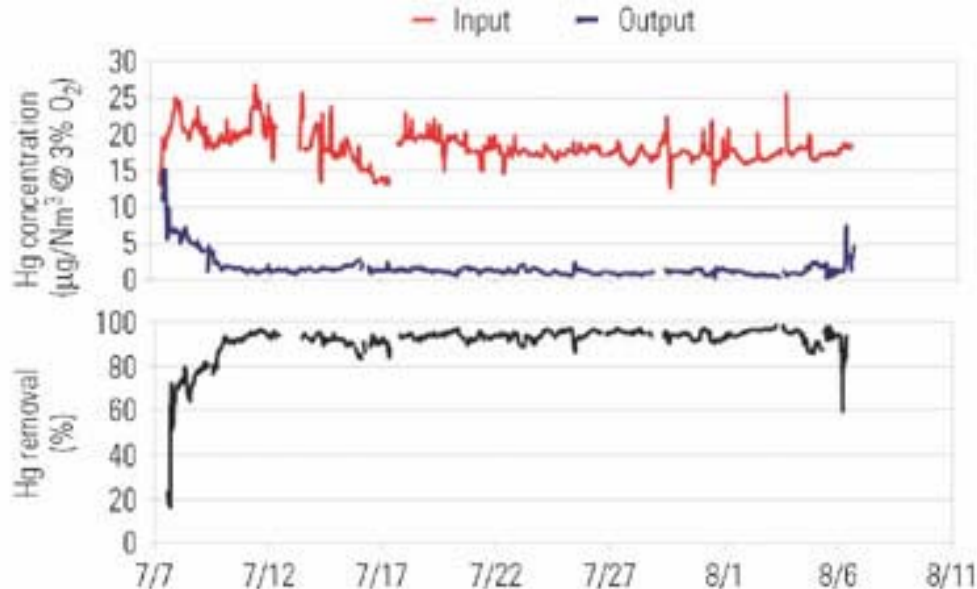


# Evaluation of Sorbent Injection for Mercury Control

## *Preliminary Results*

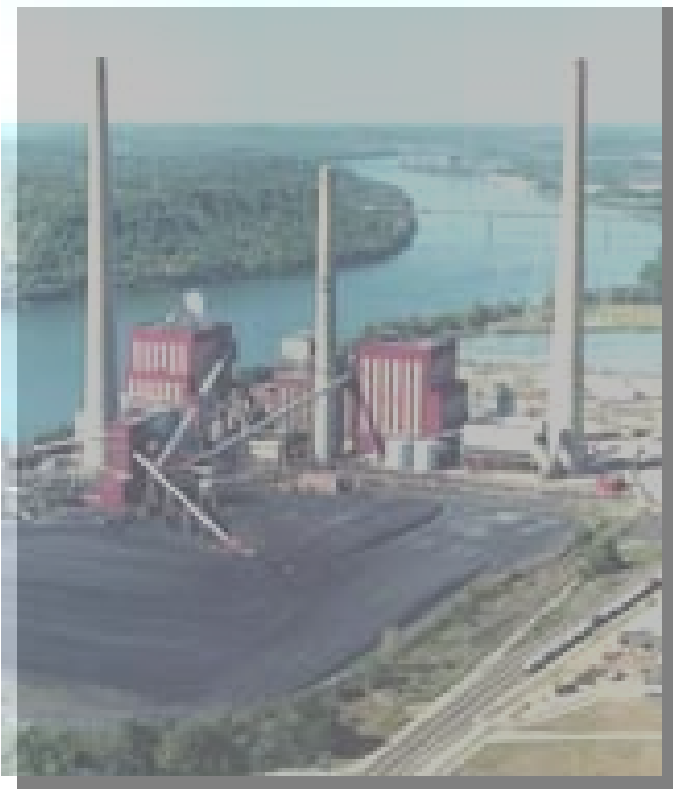
### ***Sunflower Electric's Holcomb Station***

- Baseline mercury removal < 20%
- 30-day long-term test using halogenated activated carbon (Norit FGD E-3)
- Average mercury removal 93% at 1.2 lb/MMacf



# Amended Silicates for Mercury Control

## *ADA Technologies*



- Evaluate a new non-carbon sorbent, Amended Silicates™
- Avoid impact on fly ash sales
- Full-scale testing at **Cinergy's Miami Fort Station Unit 6**
  - burns bituminous coal and equipped with ESP

# Sorbent Injection for Small ESP Mercury Control

## *URS Group*

- Evaluate sorbents injected upstream of ESP with small specific collection area (SCA)
- Full-scale testing at ***Southern Company's Plant Yates Unit 1 & 2***
  - Unit 1 equipped with ESP (173 SCA) and wet FGD
  - Unit 2 equipped with ESP (144 SCA) and  $\text{NH}_3/\text{SO}_3$  conditioning
  - Both units burn bituminous coal

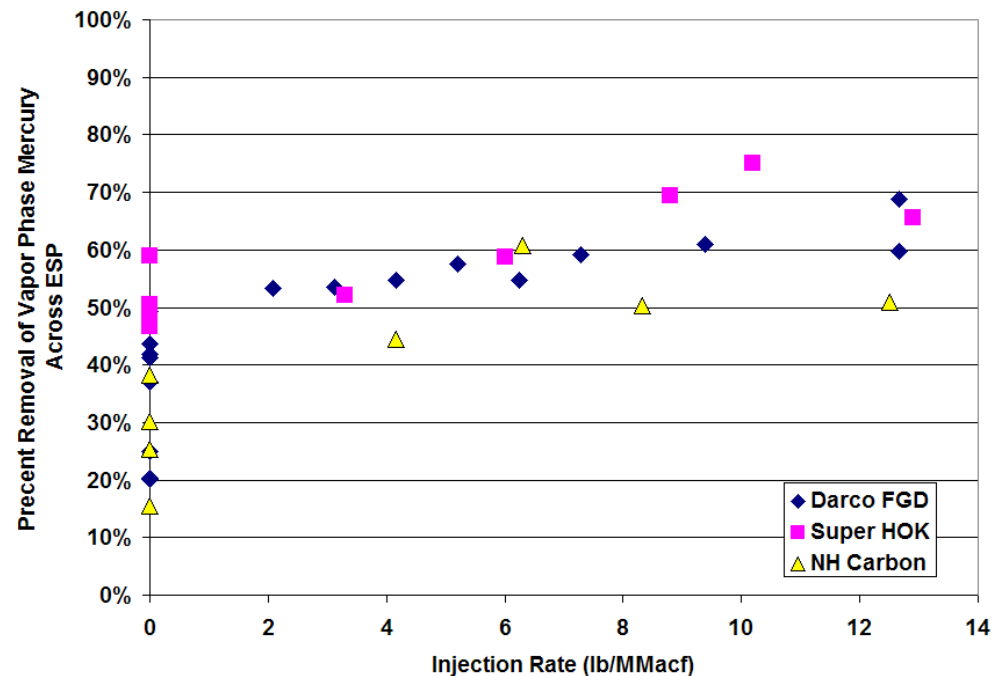


# Sorbent Injection for Small ESP Mercury Control

## *Preliminary Results*

### **Plant Yates Unit 1**

- Short-term parametric testing
- Average baseline mercury removal ~34%
- Additional 30 – 40% mercury removal with sorbent injection at ~6 lb/MMacf
- No significant increase in ESP outlet particulates
- Similar results on Unit 2



# Pilot Testing of Mercury Oxidation Catalysts for Upstream of Wet FGD Systems

*URS Group*

- Evaluate honeycomb catalyst system for oxidizing elemental mercury
- Removal in downstream wet lime or limestone FGD systems

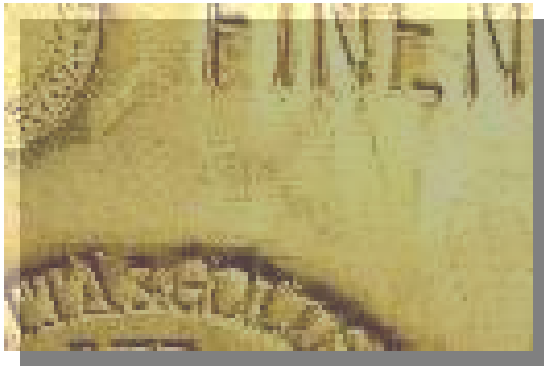


- Pilot-scale testing conducted over 14 months at two sites:
- ***TXU's Monticello Station Unit 3***  
– burns Texas lignite
- ***Southern Company's Plant Yates*** – burns bituminous coal
- Both plants equipped with ESP and wet FGD



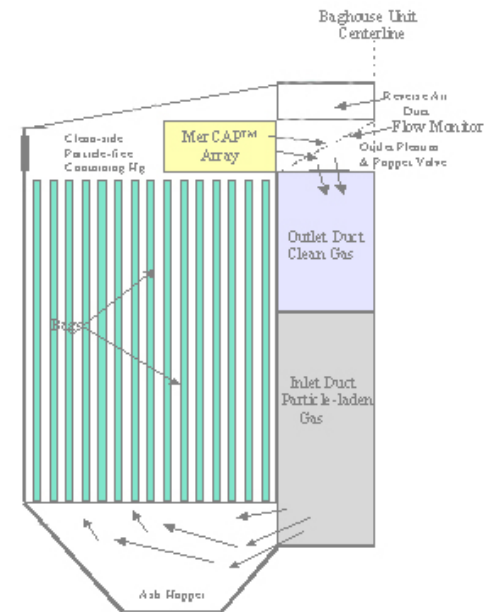
# Evaluation of MerCAP for Power Plant Mercury Control

*URS Group*



- Evaluate EPRI's Mercury Control via Adsorption Process (MerCAP<sup>TM</sup>) technology
- Regenerable, gold-coated fixed-structure sorbent
- Mercury not contained in combustion by-products

- Testing at two sites over a six month period:
- **Great River Energy's Stanton Station Unit 10**  
– burns ND lignite coal and equipped with SDA/FF (Full-scale at 6 MW equivalent)
- **Southern Company's Plant Yates Unit 1**  
– burns bituminous coal and equipped with ESP and wet FGD (Pilot-scale at 1 MW)



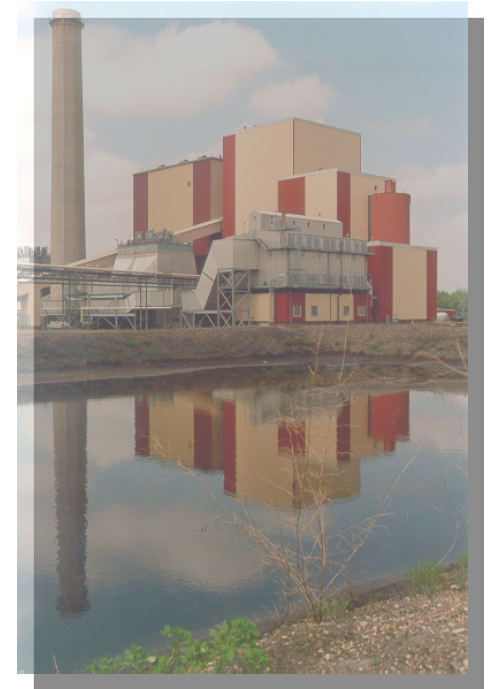


# Evaluation of MerCAP for Power Plant Mercury Control

## *Preliminary Results*

### ***Great River Energy's Stanton Unit 10***

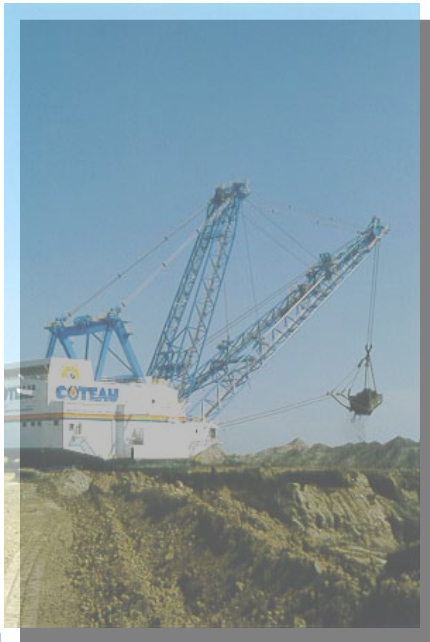
- Baseline mercury capture <10% across SDA/FF
- Full-scale testing results a good news – bad news story
- Initial 24-hrs mercury removal ~90% across gold plates
- After 24-hrs mercury removal decreased to 40% to 50%
- After one-month mercury removal stabilized at 30% to 40%
- What's next? Revise gold-plate spacing from 1" to 1/2"



# Enhancing Carbon Reactivity in Mercury Control in Lignite-Fired Systems

## *UNDEERC*

- Evaluate two approaches:
  - Use of chlorine-based additive to coal and activated carbon sorbent
  - Use of chemically-treated sorbents



- Full-scale testing at four sites burning North Dakota lignite coal:
- ***Basin Electric's Leland Olds Station Unit 1***
  - equipped with ESP
- ***Basin Electric's Antelope Valley Station Unit 1***
  - equipped with SDA/FF
- ***Great River Energy's Stanton Station Unit 1***
  - equipped with ESP
- ***Great River Energy's Stanton Station Unit 10***
  - equipped with SDA/FF



# Enhancing Carbon Reactivity in Mercury Control in Lignite-Fired Systems

## *Preliminary Results*

### ***Basin Electric's 220 MW Leland Olds Station Unit 1***

- Baseline mercury removal ~15% across ESP
- Average mercury removal ~63% during one-month long-term testing with coal additive equivalent to 500 ppm chlorine in coal and 3 lb/MMacf sorbent injection

### ***Great River Energy's 60 MW Stanton Station Unit 10***

- Baseline mercury removal across SDA/FF <10%
- Mercury removal ranged from 65% to 75% during one-month long-term testing with halogenated activated carbon injection at 1 lb/MMacf (Norit's FGD E-3)



# Mercury Oxidation Upstream of an ESP and Wet FGD *UNDEERC*

- Evaluate chloride-based additive to increase mercury oxidation upstream of ESP and wet scrubber
- Full-scale testing at two sites burning lignite coal and equipped with both ESP and wet FGD:
  - ***Minnkota Power Cooperative's Milton R. Young Station Unit 2***  
– burns ND lignite
  - ***TXU's Monticello Station Unit 3***  
– burns TX lignite



# Advanced Utility Mercury Sorbent Field-Testing Program

## *Sorbent Technologies*

- Evaluate brominated powdered activated carbon (B-PAC) sorbent
- Full-scale testing at two sites:
  - ***Duke Energy's Buck Station***
    - burns bituminous coal and equipped with hot-side ESP
  - ***Detroit Edison's St. Clair Station***
    - burns blend of bituminous and subbituminous coal and equipped with ESP

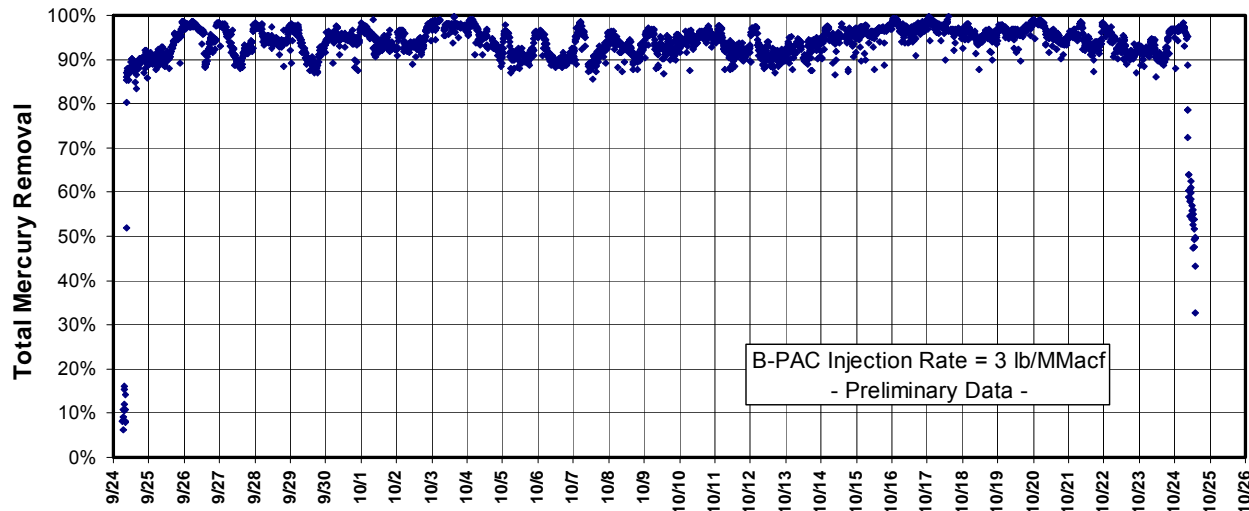


# Advanced Utility Mercury Sorbent Field-Testing Program *Preliminary Results*

## ***Detroit Edison's St. Clair Station***

- Baseline mercury removal across ESP varied from 0% to 40%
- One month long-term test using brominated activated carbon injection (B-PAC)
- Average mercury removal 94% at 3 lb/MMacf

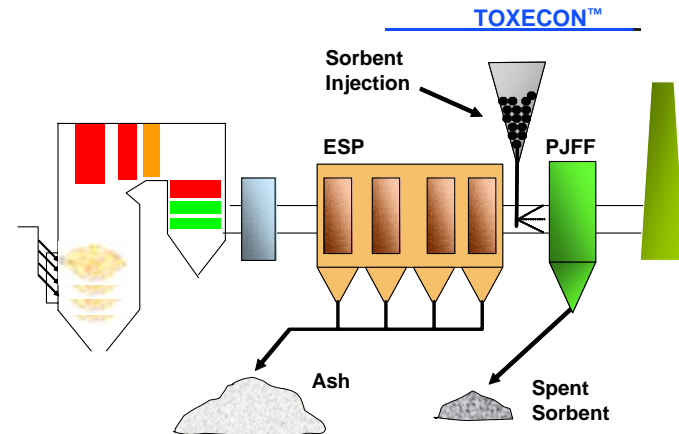
Detroit Edison St. Clair Plant - Total Hg Removal  
Thirty Day Average = 94%



# Field-Testing of Activated Carbon Injection Options for Mercury Control at TXU's Big Brown Station

## UNDEERC

- Evaluate several activated carbon sorbents in a TOXECON configuration



- Full-scale testing at **TXU's Big Brown Station**
  - burns blend of lignite and PRB coal and equipped with ESP and COHPAC fabric filter



# Field Demonstration of Enhanced Sorbent Injection for Mercury Control

## *ALSTOM*

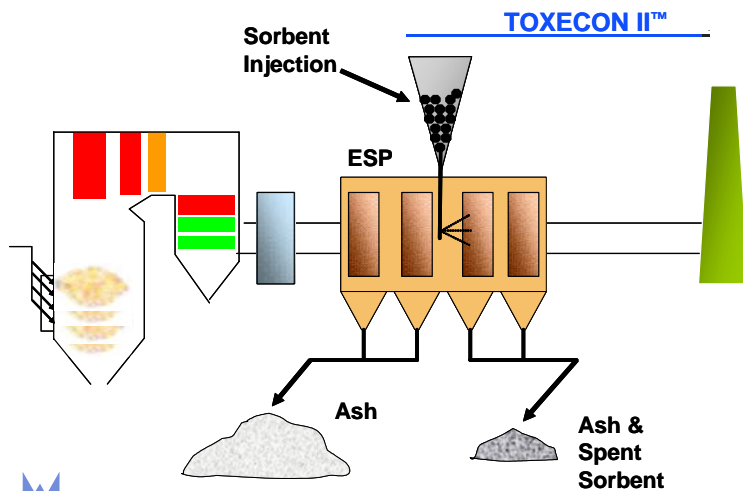
- Evaluate proprietary chemically-treated activated carbon sorbent injection process – **Mer-Cure™**
- Full-scale testing at three sites:
  - ***Basin Electric's Leland Olds Station Unit 1***
    - burns ND lignite and equipped with ESP
  - ***Reliant Energy's Portland Station***
    - burns bituminous coal and equipped with ESP
  - ***PacificCorp's Dave Johnston Station***
    - burns PRB coal and equipped with ESP



# Low Cost Options for Moderate Levels of Mercury Control

## ADA-ES

- Full-scale sorbent injection for hot-side ESPs will be tested at two sites:
  - **MidAmerican's Council Bluffs Energy Center**
    - burns PRB coal
  - **MidAmerican's Louisa Station**
    - burns PRB coal



- TOXECON II will be tested at two sites:
  - **AEP's Gavin Station**
    - burns bituminous coal and equipped with ESP and wet FGD
  - **Entergy's Independence Station**
    - burns PRB coal and equipped with ESP

# Brominated Sorbents for Small Cold-Side ESPs, Hot-Side ESPs, and Fly Ash use in Concrete *Sorbent Technologies*

- Evaluate brominated powdered activated carbon (B-PAC) sorbent
- Full-scale testing at three sites:
  - ***Midwestern Generation's Crawford Station***  
– burns PRB coal and equipped with cold-side ESP (112 SCA)
  - ***Progress Energy's Lee Station***  
– burns bituminous coal and equipped with cold-side ESP (300 SCA)
  - ***Midwestern Generation's Will County Station***  
– burns PRB coal and equipped with hot-side ESP (173 SCA)



# Field Testing of a Wet FGD Additive for Enhanced Mercury Control

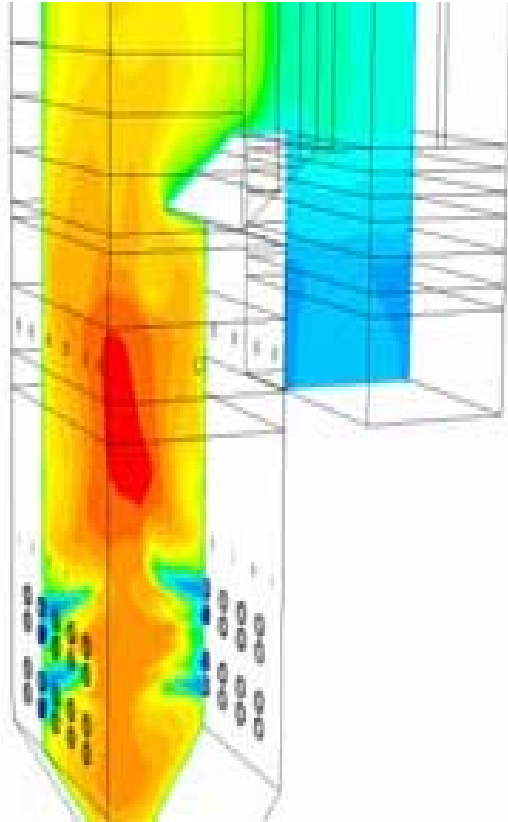
## *URS Group*

- Evaluate chemical additive in wet FGD systems to prevent re-emission of mercury
- Full-scale testing at three sites equipped with ESP and wet FGD:
  - ***TXU's Monticello Station***
    - burns lignite coal
  - ***Southern Company's Plant Yates***
    - burns bituminous coal
  - ***AEP's Conesville Station***
    - burns bituminous coal



# Demonstration of Integrated Approach to Mercury Control at John Sevier Station

*GE EER*



- Evaluate boiler combustion modifications for combined NO<sub>x</sub> and mercury control
- Full-scale testing at ***TVA's John Sevier Station***
  - burns bituminous coal and equipped with ESP

# Full-Scale Demonstration of Toxecon™ Retrofit for Mercury and Multi-Pollutant Control

- **Demonstrate:**
  - Multi-pollutant control with PRB coal
    - 90% Hg reduction
    - 70% SO<sub>2</sub> reduction
    - 30% NO<sub>x</sub> reduction
  - Testing to begin in January 2006



*We Energies Presque Isle  
Power Plant*



# Summary

- **Significant advances made in research and development of technology for capturing mercury from coal-fired power plants**
- **Sorbent (e.g., activated carbon) injection and oxidation technologies (coupled with scrubbers) are leading approaches for coal-fired power plant mercury control**



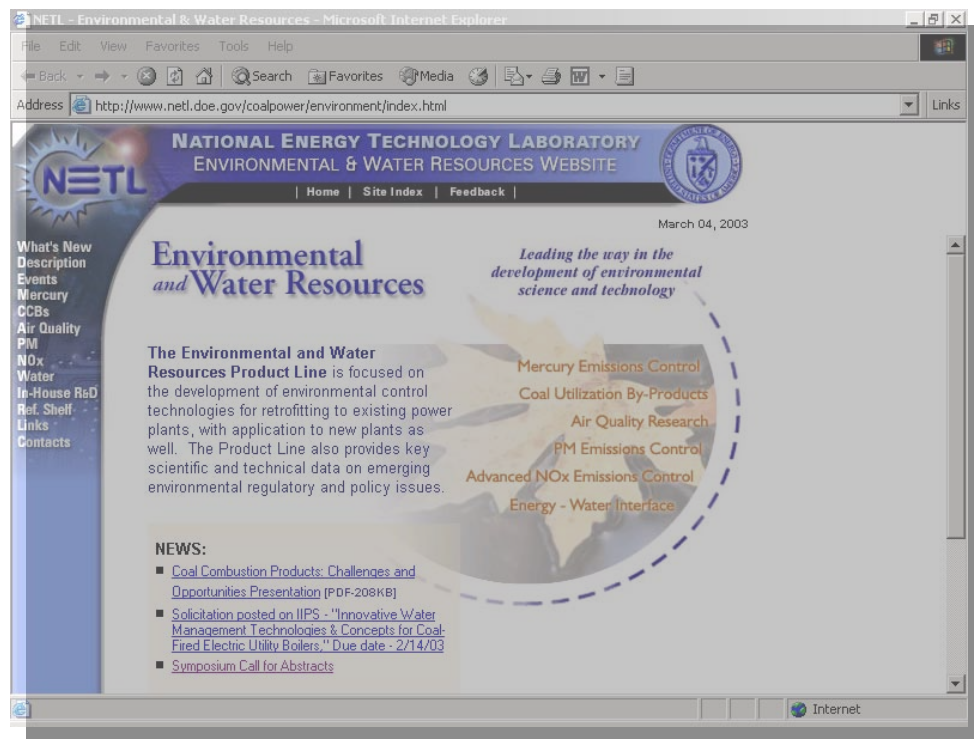


# Future Plans

- **Continue Phase II field testing of technology capable of achieving 50-70% Hg removal through FY06-FY07**
- **Issue competitive solicitation in July 2005 for Phase III field testing of control technologies capable of  $\geq 90\%$  Hg capture**



# DOE/NETL Environmental and Water Resources (Innovations for Existing Plants Program)



To find out more about DOE-NETL's Hg R&D activities visit us at:  
<http://www.netl.doe.gov/coal/E&WR/index.html>

