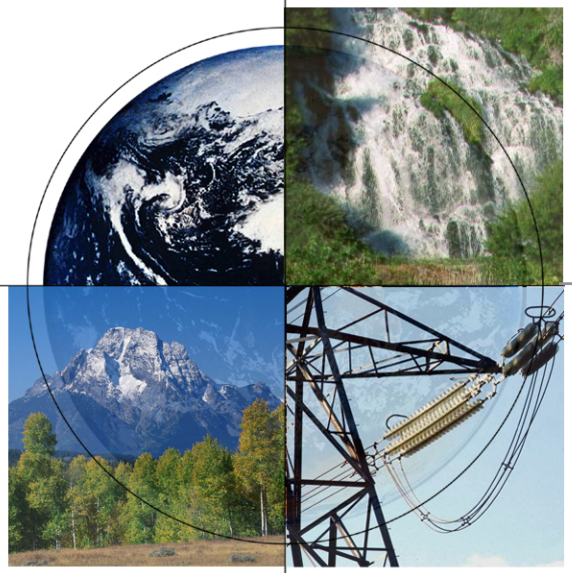
U.S. Department of Energy's Mercury Control Technology R&D Program for Coal-Fired Boilers



Working Session of the New Hampshire House Science, Technology, & Energy Committee

April 26, 2005
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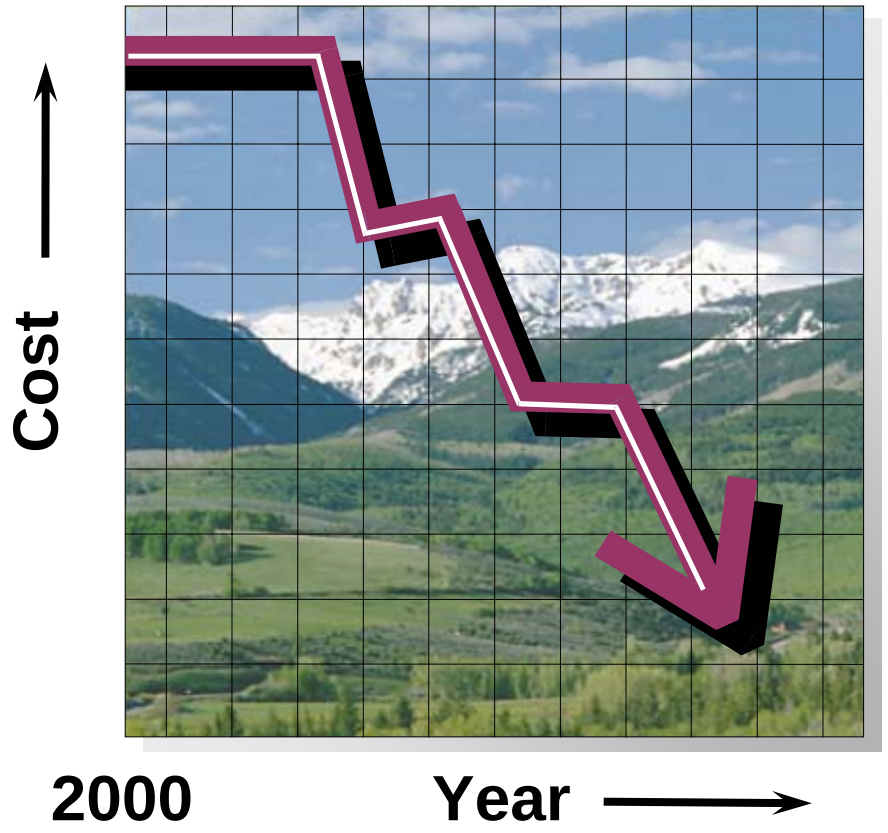
Mercury Control Technology Field Testing Program

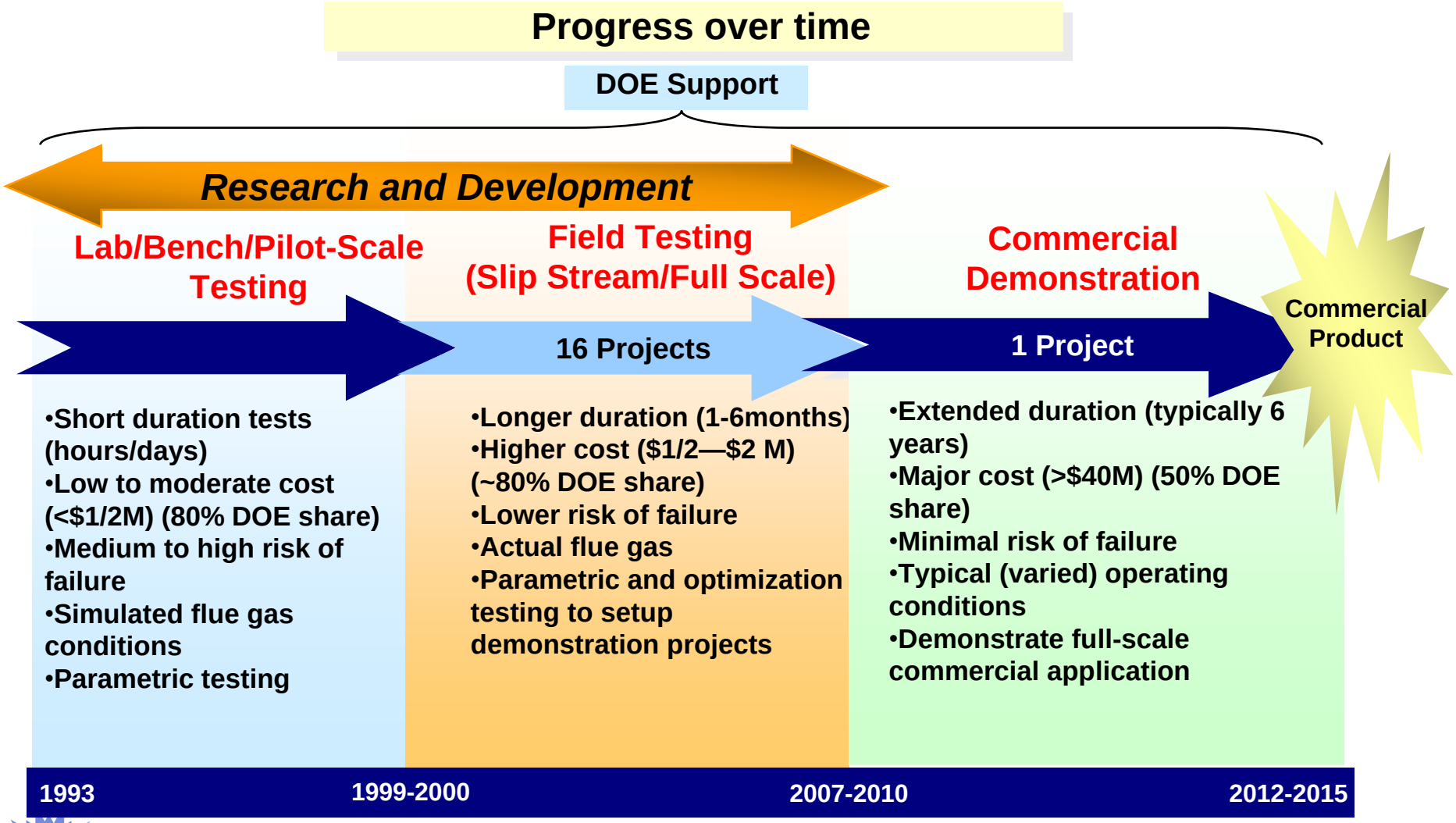
Performance/Cost Objectives

- Have technologies ready for <u>commercial demonstration</u> by 2007 for all coals
- Reduce “uncontrolled” Hg emissions by 50-70%
- Reduce cost by 25-50% compared to baseline cost estimates



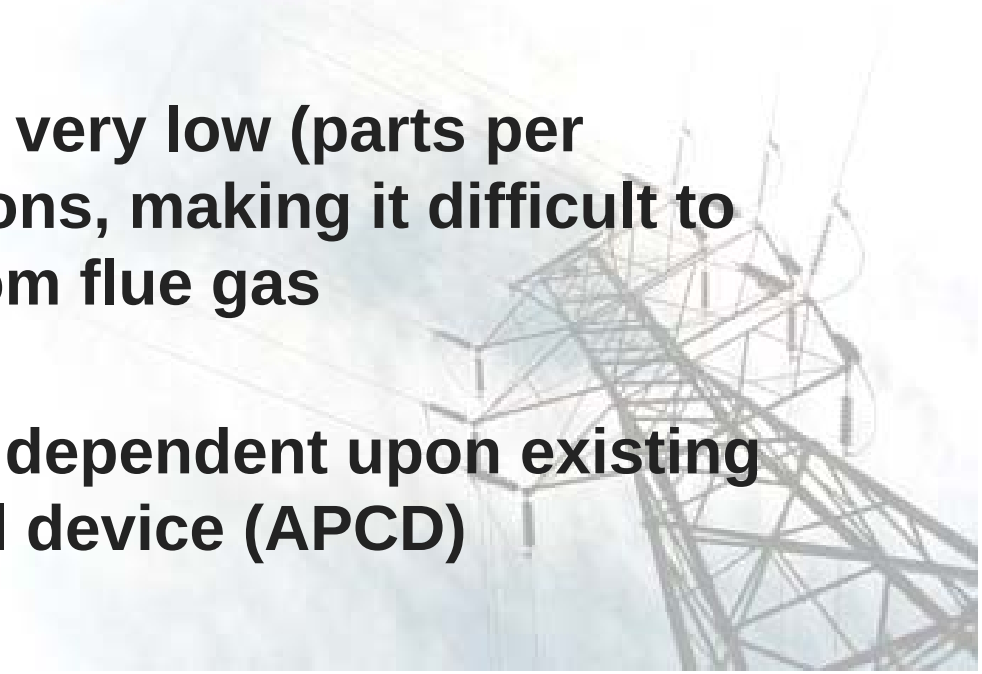
Baseline Costs: $50,000 - $70,000 / lb Hg Removed

Stages of Mercury Control Technology Development
DOE RD&D Model



Key Facts About Power Plant Mercury

- **Unlike sulfur dioxide or nitrogen oxides, form (species) of mercury depends on coal type, fly ash composition, and other factors – that is, *"one size doesn't fit all"***
- **Mercury is found in very low (parts per billion) concentrations, making it difficult to find and remove from flue gas**
- **Removal efficiency dependent upon existing air pollution control device (APCD)**



Key Takeaways

- **Significant strides have been made in developing mercury control technology over the past several years, but more R&D is needed**
- **Activated carbon/sorbent injection and oxidation systems (i.e., catalysts, chemical additives) are most promising Hg control technologies**
- **Significant variability in Hg speciation depending on coal type and other factors**
- **DOE's current field testing activity is an R&D program**
- **Further long-term field testing is needed to bring technology to commercial-demonstration readiness**
- **DOE's RD&D model projects broad commercial availability in 2012-2015**

Field Testing to Address Technical/Cost Uncertainties

- ***General***
  - ***Performance over longer periods of operation***
  - ***Cost of mercury control***
  - ***By-product use and disposal***
  - **Impacts of load variation**
  - **Effect of variations in coal-Hg content**
  - ***Capture effectiveness with low-rank coals and coal blends***
- ***Activated Carbon/Sorbent Injection***
  - **Understanding of in-flight capture**
  - **Optimize injection lance configuration**
  - ***Effectiveness of chemically modified sorbents/impacts on air emissions***
  - **Sorbent feed rate and costs**
  - ***Effectiveness with small SCA ESPs***
  - **Impact on ESP performance and bag life**
- ***Enhanced Scrubber Capture/Oxidation***
  - ***Hg^{++} reduction/re-emission***
  - **Effectiveness of oxidation additives and catalysts**

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**

Field testing at 28 different coal-fired units --representing approximately 2.3% of 1,165 existing coal-fired generating units.

NETL/DOE Mercury R&D Field Testing Phase II Projects

Evaluation of Sorbent Injection for Mercury Control	ADA-ES
Low-Cost Options for Moderate Levels of Mercury Control	ADA-ES
Field Demonstration of Enhanced Sorbent Injection for Mercury Control	ALSTOM
Demonstration of Amended Silicates for Mercury Control	Amended Silicates
Demonstration of Integrated Approach to Mercury Control	GE-EERC
Enhancing Carbon Reactivity in Mercury Control in Lignite-Fired Systems	UNDEERC
Mercury Oxidation Upstream of an ESP and Wet FGD	UNDEERC
Field Testing of Activated Carbon Injection Options for Mercury Control	UNDEERC
Sorbent Injection for Small ESP Mercury Control	URS Group
Pilot Testing of Mercury Oxidation Catalysts for Upstream of Wet FGD Systems	URS Group
Evaluation of MerCAP for Power Plant Mercury Control	URS Group
Field Testing of a Wet FGD Additive for Enhanced Mercury Control	URS Group
Advanced Utility Mercury-Sorbent Field-Testing Program	Sorbent Technologies
Brominated Sorbents for Cold-Side ESPs, Hot-Side ESPs, and Fly Ash Use in Concrete	Sorbent Technologies

DOE/NETL Phase II Mercury Control Field Testing Technology Matrix

Coal Rank	Cold-side ESP (low SCA)	Cold-side ESP (medium or high 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 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

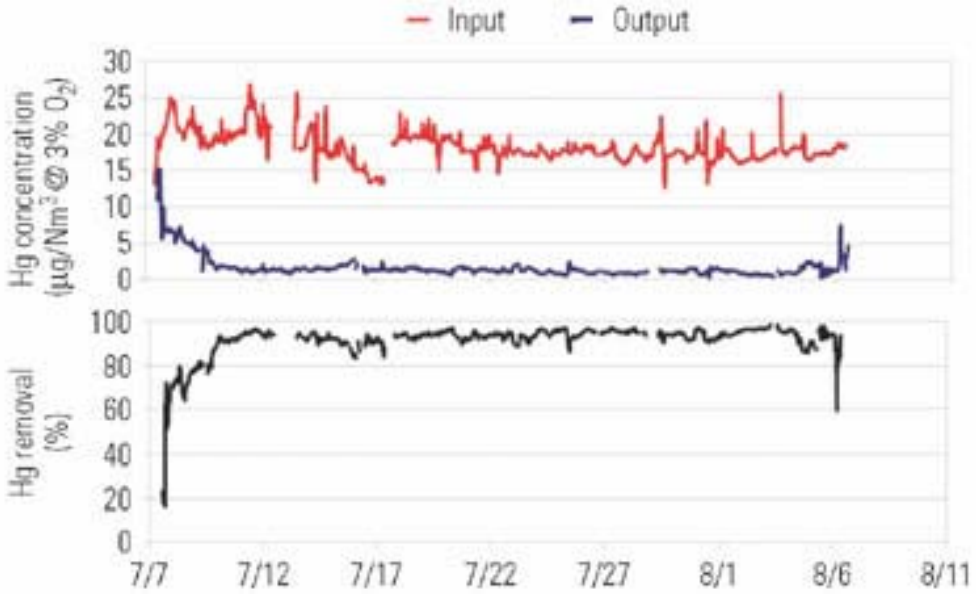
Evaluation of Sorbent Injection for Mercury Control -- *ADA-ES*

- 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

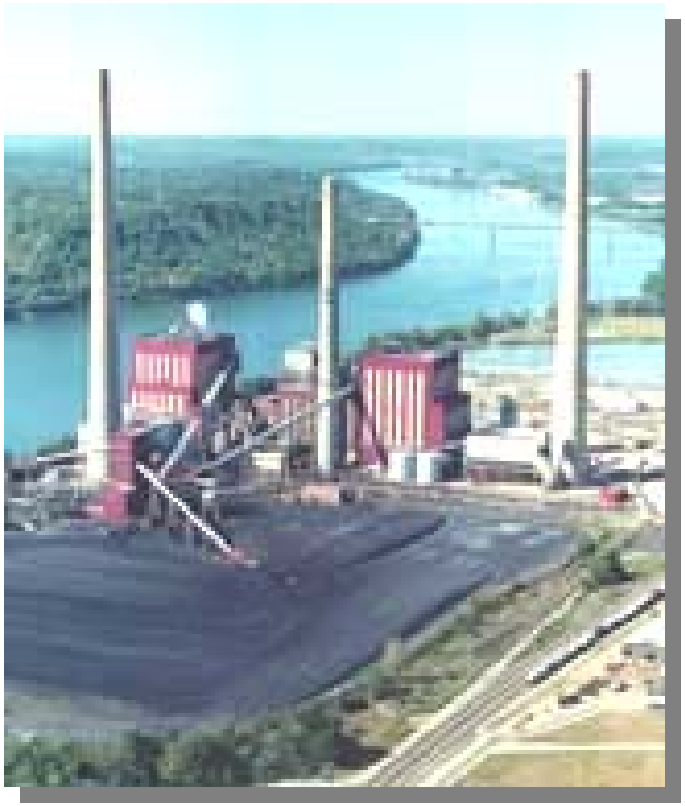
Evaluation of Sorbent Injection for Mercury Control
Preliminary Results

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

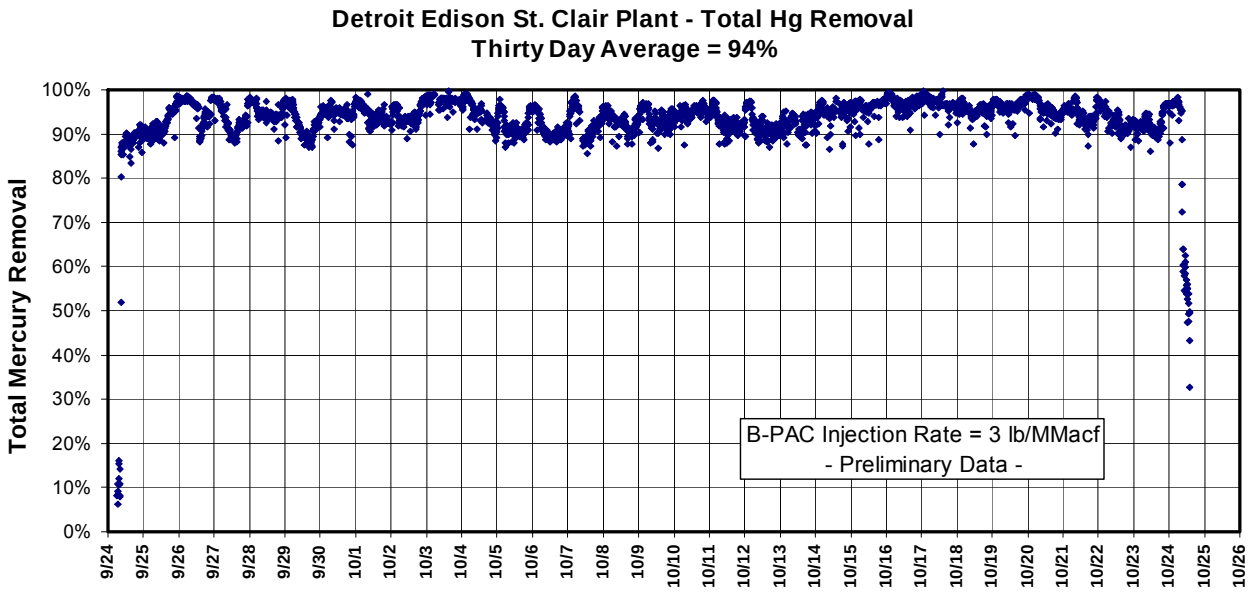
Advanced Utility Mercury Sorbent Field Testing -- *Sorbent Technologies*

- 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
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



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)

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Sorbent Injection for Small ESP Mercury Control
URS Group

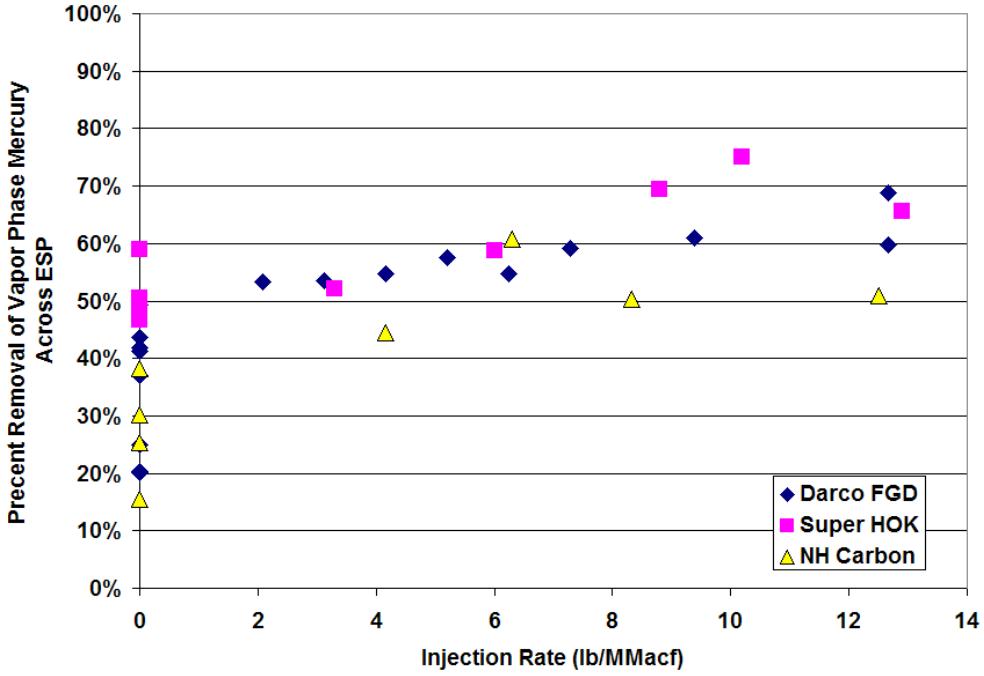
- Evaluate sorbents injected upstream of ESP with small specific collection area (SCA)

- 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 NH_3/SO_3 conditioning
  - Both units burn bituminous coal

Sorbent Injection for Small ESP Mercury Control
Preliminary Results

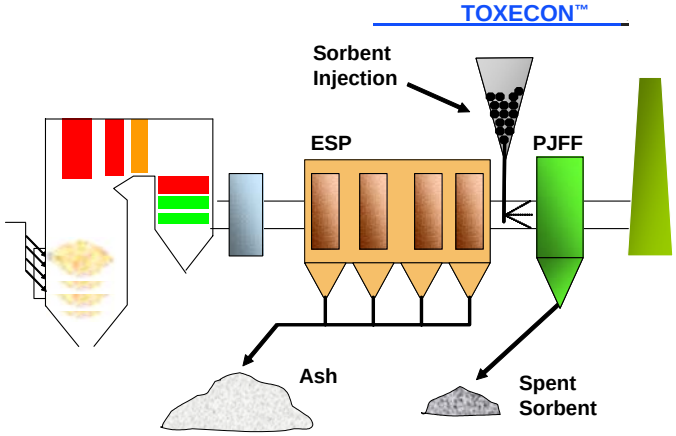
Plant Yates Unit 1

- 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



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

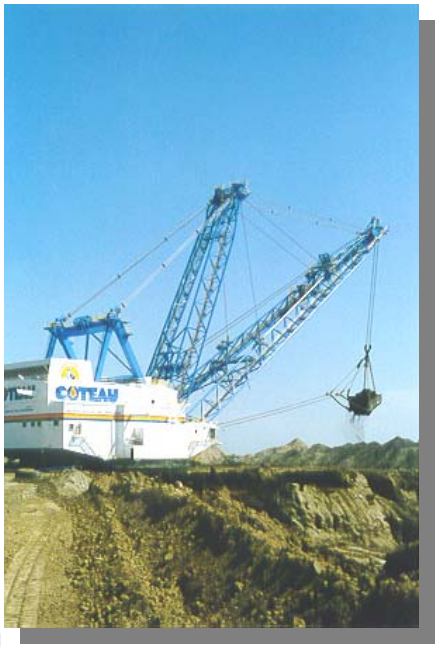
Field Testing of Enhanced Sorbent Injection for Mercury Control -- *ALSTOM*

- 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

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

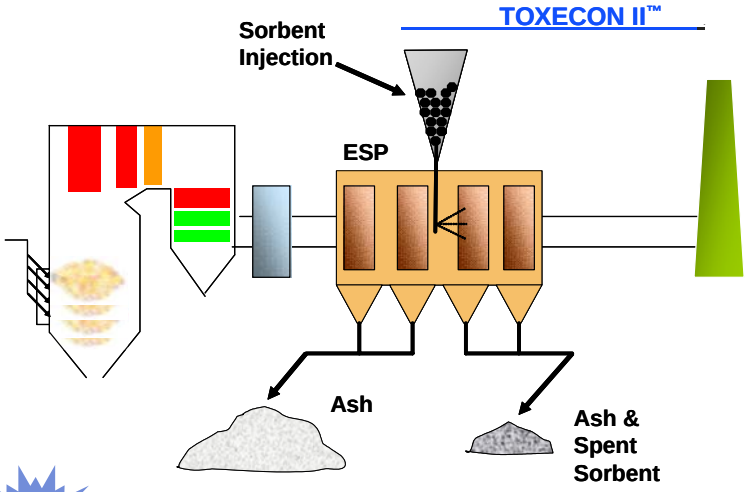
- Baseline mercury removal ~15% across ESP
- Average mercury removal ~63% during one-month long-term testing with coal additive equivalent to 500 ppm chlorine in coal and 3 lb/MMacf sorbent injection

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)

Low Cost Options for Moderate Levels of Mercury Control -- *ADA-ES*

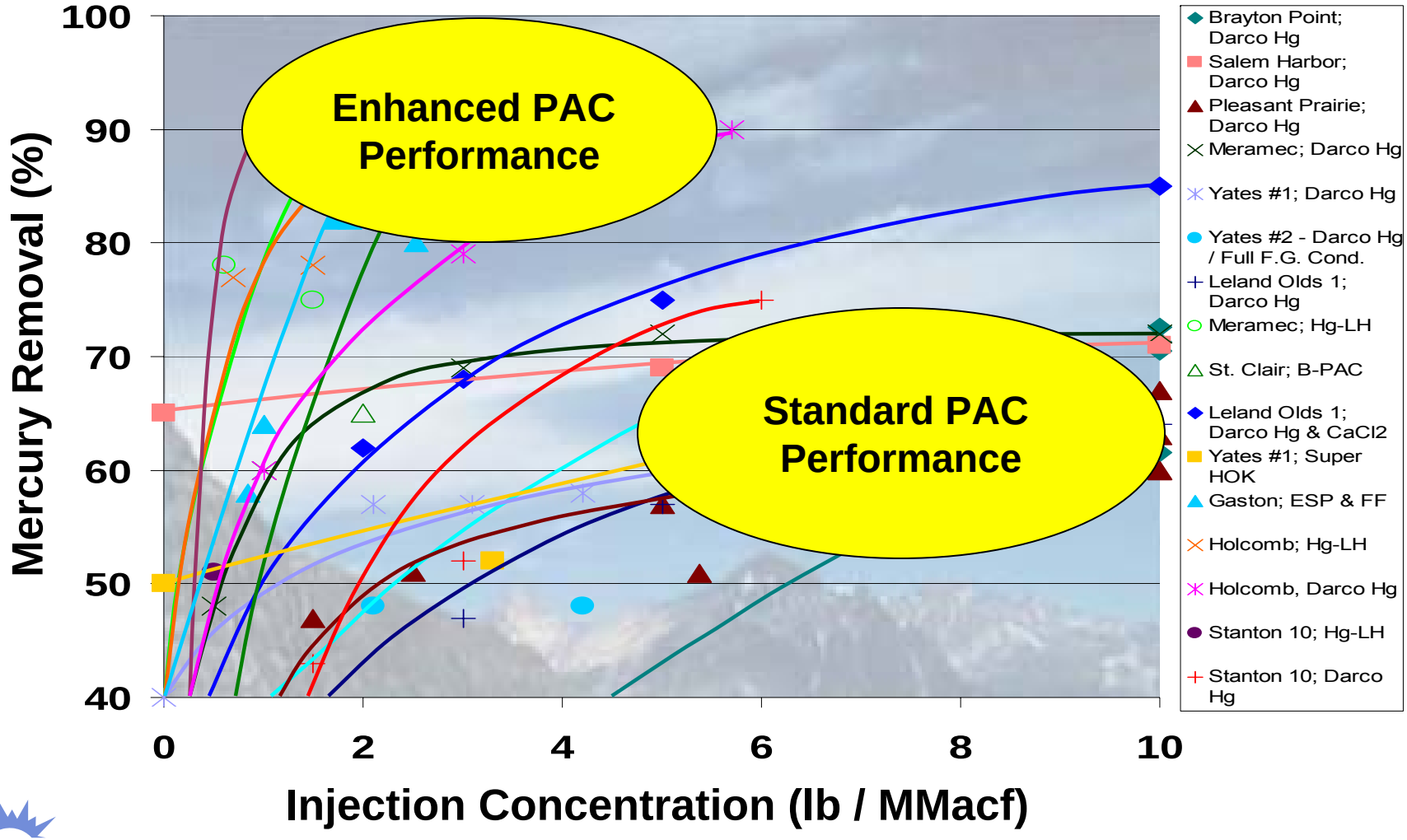
- Full-scale sorbent injection for hot-side ESPs will be tested at two sites:
  - ***MidAmerican's Council Bluffs Energy Center***
    - burns PRB coal
  - ***MidAmerican's Louisa Station***
    - burns PRB coal



- 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

Field Testing Results 2001 – 2004

Comparison of Standard & Enhanced PAC



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

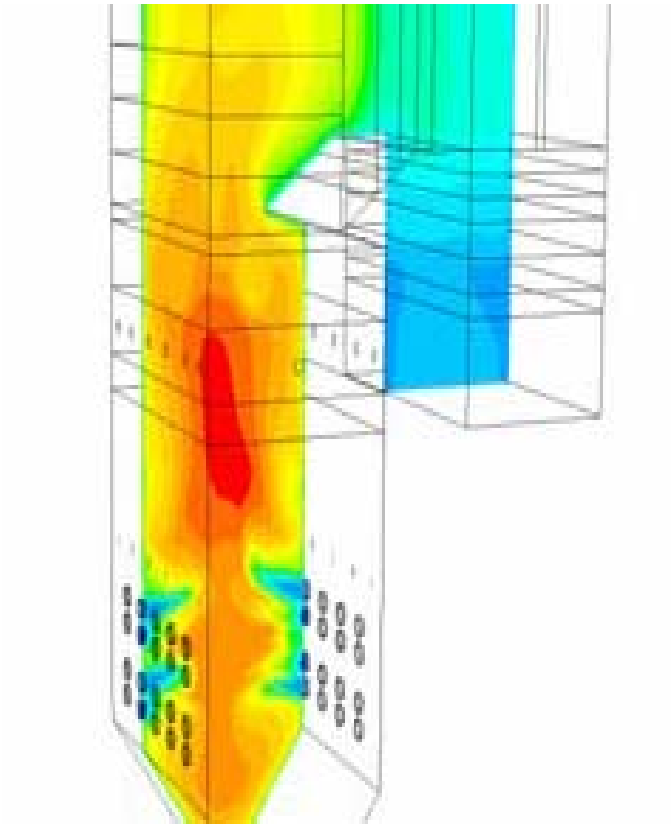
Mercury Oxidation Upstream of an ESP and Wet FGD -- *UNDEERC*

- 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

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**

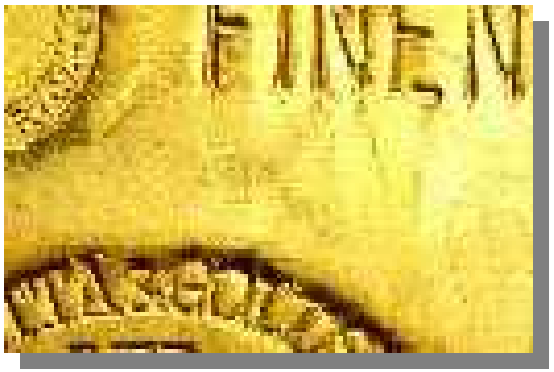
Demonstration of Integrated Approach to Mercury Control -- *GE-EERC*



- Evaluate boiler combustion modifications for combined NOx and mercury control
- Full-scale testing at ***Progress Energy's Lee Station***

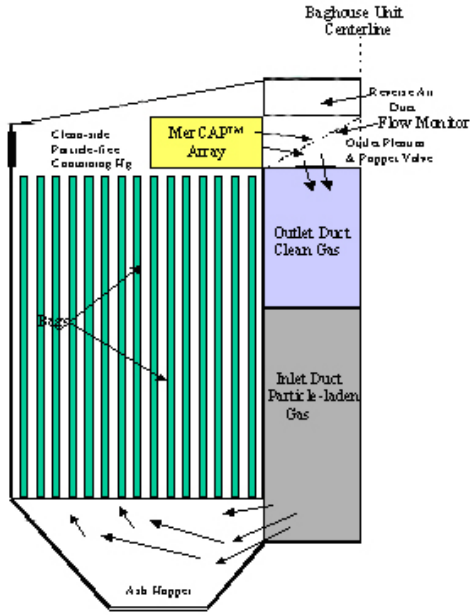
  – burns bituminous coal and equipped with ESP

Evaluation of MerCAP for Mercury Control
URS Group



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

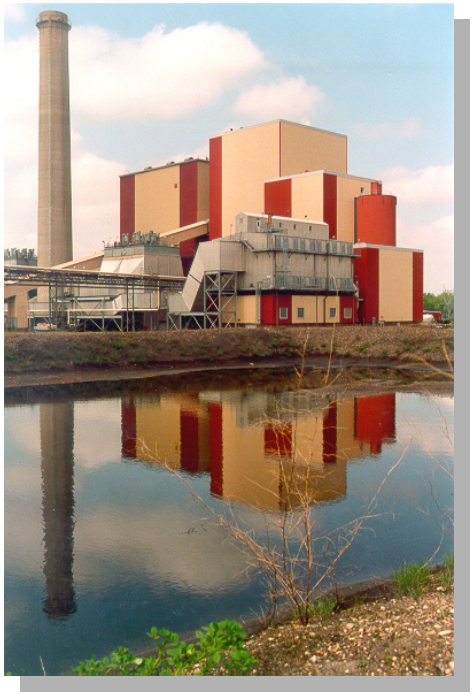
- Testing at two sites over a six month period:
  - *Great River Energy's Stanton Station Unit 10* **burns ND lignite coal and equipped with SDA/FF (Full-scale at 6 MW equivalent)**
  - *Southern Company's Plant Yates Unit 1* **burns bituminous coal and equipped with ESP and wet FGD (Pilot-scale at 1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



Evaluation of MerCAP for 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 ½"



Key Takeaways

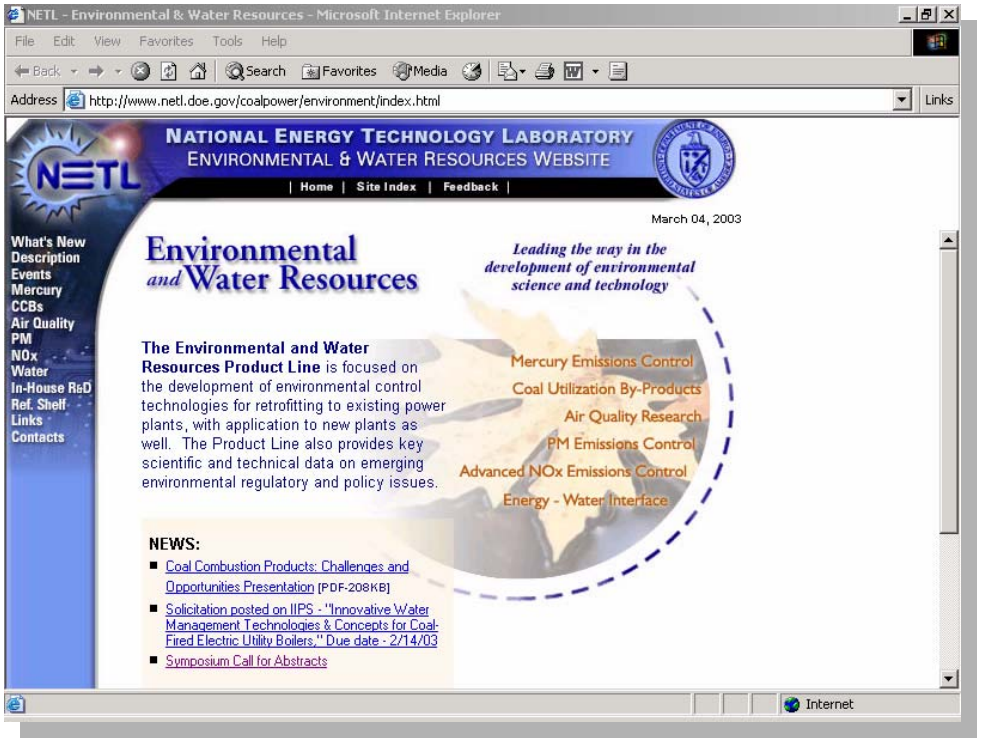
- **Significant strides have been made in developing mercury control technology over the past several years, but more R&D is needed**
- **Activated carbon/sorbent injection and oxidation systems (i.e., catalysts, chemical additives) are most promising Hg control technologies**
- **Significant variability in Hg speciation depending on coal type and other factors**
- **DOE's current field testing activity is an R&D program**
- **Further long-term field testing is needed to bring technology to commercial-demonstration readiness**
- **DOE's RD&D model projects broad commercial availability in 2012-2015**

Future Plans

- **Continue Phase II field testing of technology capable of achieving 50-70% Hg removal through FY06-FY07**

- **Issue competitive solicitation in June 2005 for Phase III field testing of control technologies capable of ≥ 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