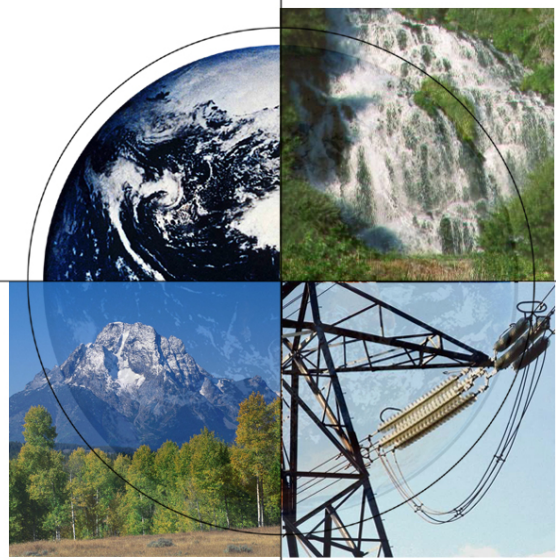
Development and Testing of Mercury Control Technology for Coal-Fired Power Plants: A U.S. Department of Energy R&D Program



Clean Air 2005
8th International Conference on Energy for a Clean Environment

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Lisbon, Portugal

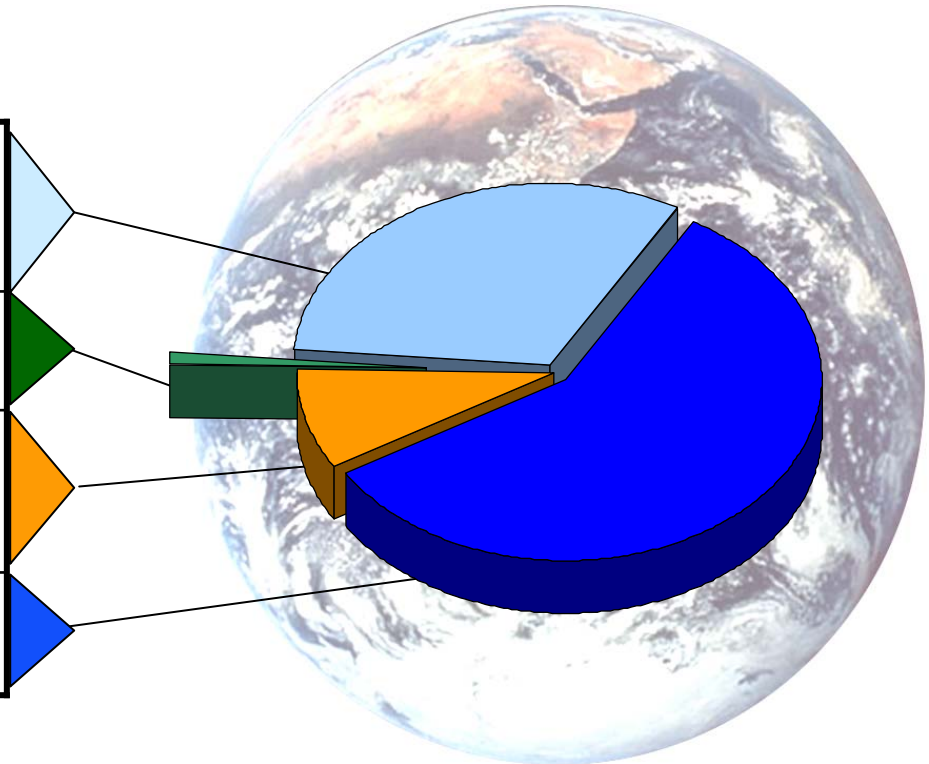
Thomas J. Feeley, III
thomas.feeley@netl.doe.gov
U.S. Department of Energy
National Energy Technology Laboratory

Presentation Outline

- **Background on Hg Emissions**
- **U.S. DOE's Hg Control Technology R&D Program**
  - Activated Carbon (Sorbent Injection)
  - Oxidation Technologies
- **Key Take Aways**

Global Mercury Emissions

Emissions from Natural Sources (Volcanoes, Forest Fires, etc.)	1540 tons
U.S. Coal-Fired Power Plants	48 tons
Re-Emission of Prior Anthropogenic Emissions	440 tons
New Anthropogenic Emissions*	2820 tons

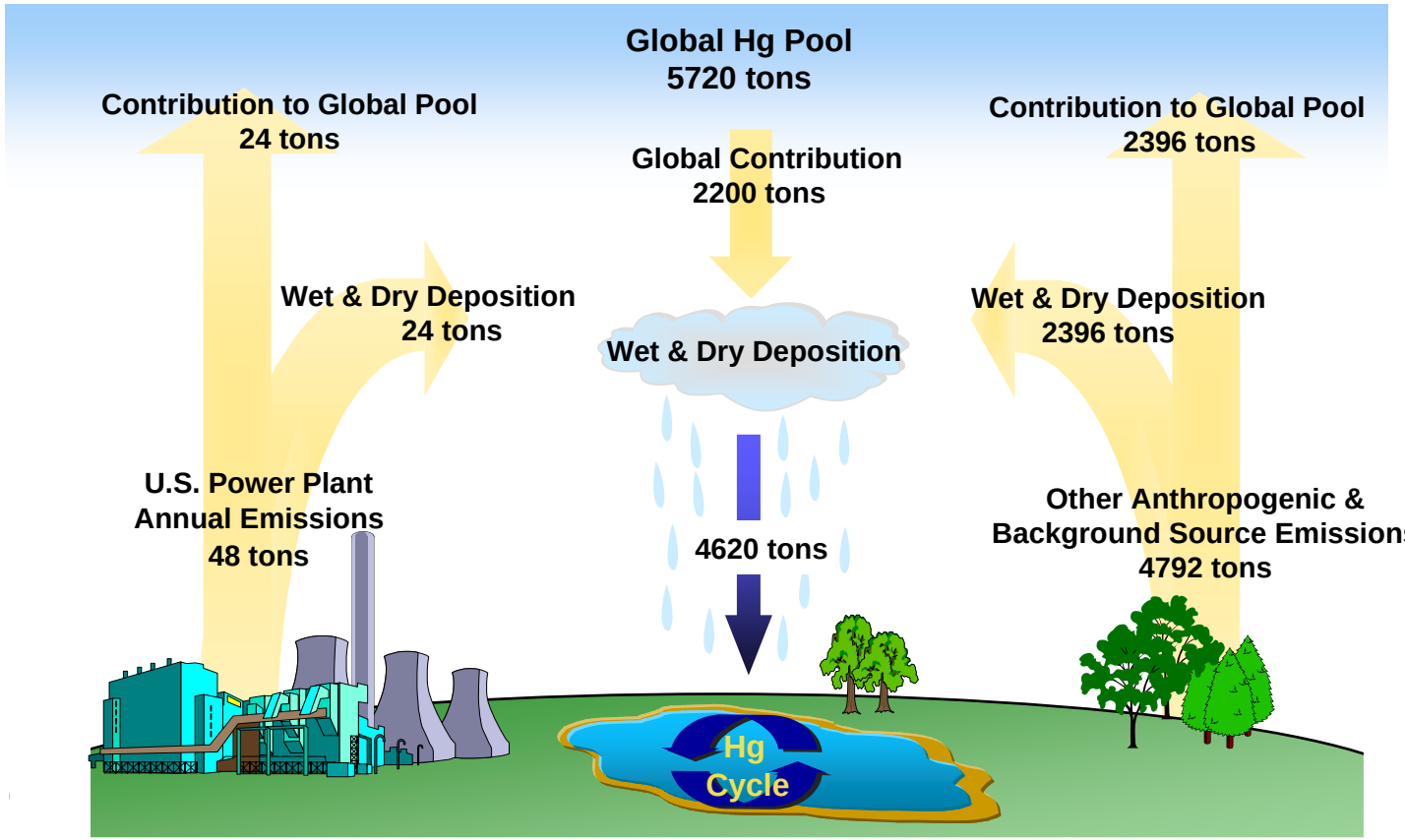


*Note: Does not include U.S. Coal-Fired Power Plant Emissions

FACT: It is estimated that U.S. coal-fired power plants emit approximately 1% of annual global mercury emissions

Source: UNEP Global Mercury Assessment, December 2002

U.S. Power Plant Contribution to the Global Mercury Cycle



Sources: United Nations Environment Programme. *Global Mercury Assessment*. Switzerland: December 2002.

U.S. Coal-Fired Power Plants Facing New EPA Emission Regulations

- **Clean Air Interstate Rule (CAIR)**
  - Announced March 10, 2005
  - Implementation via two phase Eastern regional cap & trade program
  - Phase I (2009/2010)
    - 1.5 million ton NOx cap in 2009 (53% reduction)
    - 3.6 million ton SO_2 cap in 2010 (45% reduction)
  - Phase II (2015)
    - 1.3 million ton NOx cap (61% reduction)
    - 2.5 million ton SO_2 cap (73% reduction)

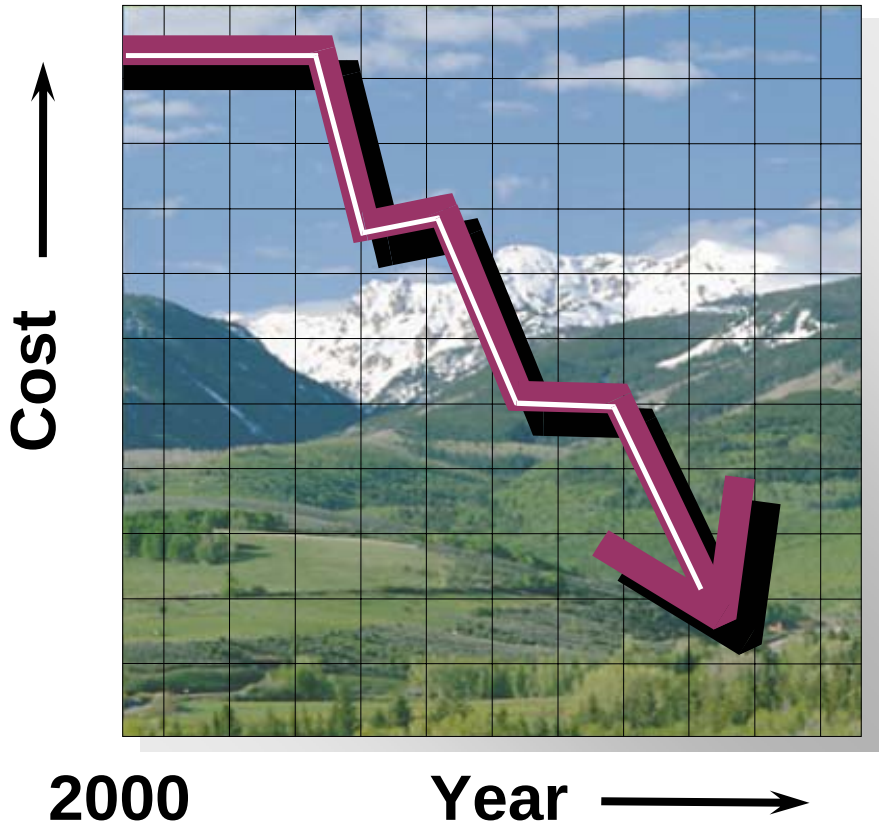
- **Clean Air Mercury Rule (CAMR)**
  - Announced March 15, 2005
  - Implementation via two phase nation-wide cap & trade program
  - Phase I (2010)
    - 38 ton mercury cap (21% reduction)
  - Phase II (2018)
    - 15 ton mercury cap (69% reduction)

Note: Percentage reductions from 2003 baseline emission levels.

Mercury Control Technology Field Testing Program

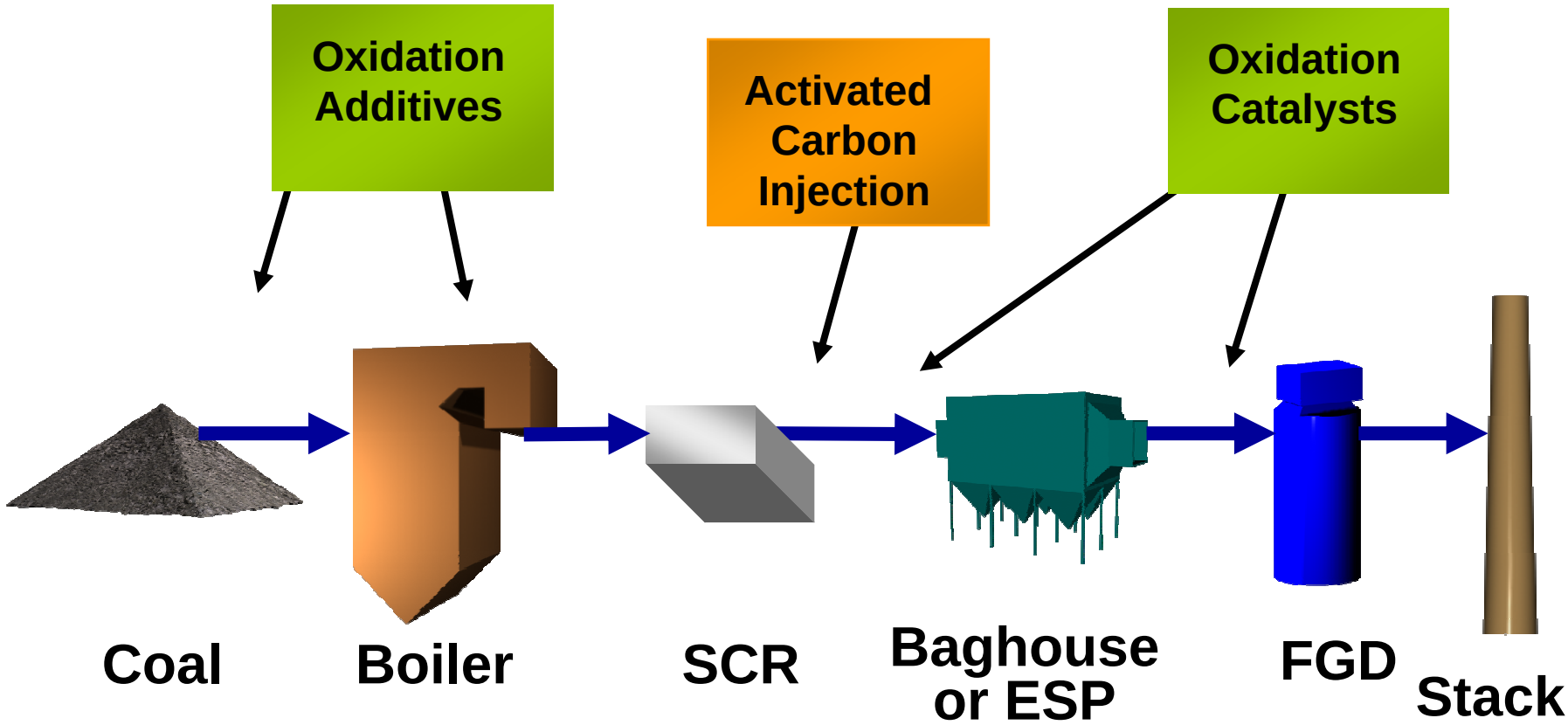
Performance/Cost Objectives

- **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
($110,000 - $154,000 / kg Hg)

Approaches for Controlling Mercury



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)**

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.

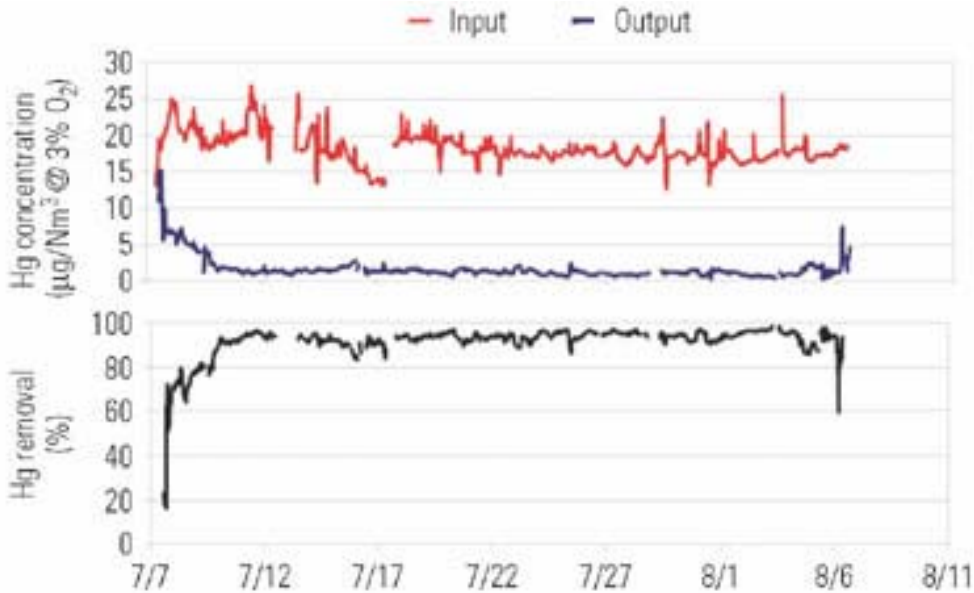
Evaluation of Sorbent Injection for Mercury Control -- *ADA-ES*

- Evaluate full-scale sorbent injection with existing pollution-control equipment at five 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
  - ***Basin Electric's Laramie River Station*** burns PRB coal and equipped with SDA/ESP

Evaluation of Sorbent Injection for Mercury Control
Preliminary Results

Sunflower Electric's Holcomb Station

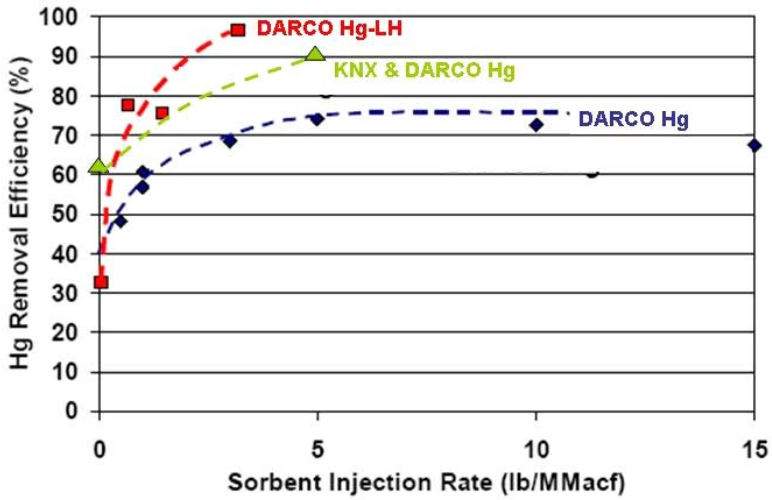
- Baseline mercury removal < 20%
- 30-day long-term test using halogenated activated carbon (DARCO Hg-LH)
- Average mercury removal 93% at 1.2 lb/10^6 ft^3 (19 kg/10^6 m^3)
- Average 0.83 lb/TBtu (0.36 pg/J) outlet mercury emission rate



Evaluation of Sorbent Injection for Mercury Control
Preliminary Results

AmerenUE's Meramec Station

- Baseline mercury removal < 20%
- Parametric testing included:
  - DARCO Hg
  - DARCO Hg w/ KNX coal additive
  - DARCO Hg-LH
- 30-day long-term test using halogenated activated carbon (DARCO Hg-LH)
- Average mercury removal 93% at 3.3 lb/10^6 ft^3 (53 kg/10^6 m^3)
- Average 0.44 lb/TBtu (0.19 pg/J) ESP outlet mercury emission rate



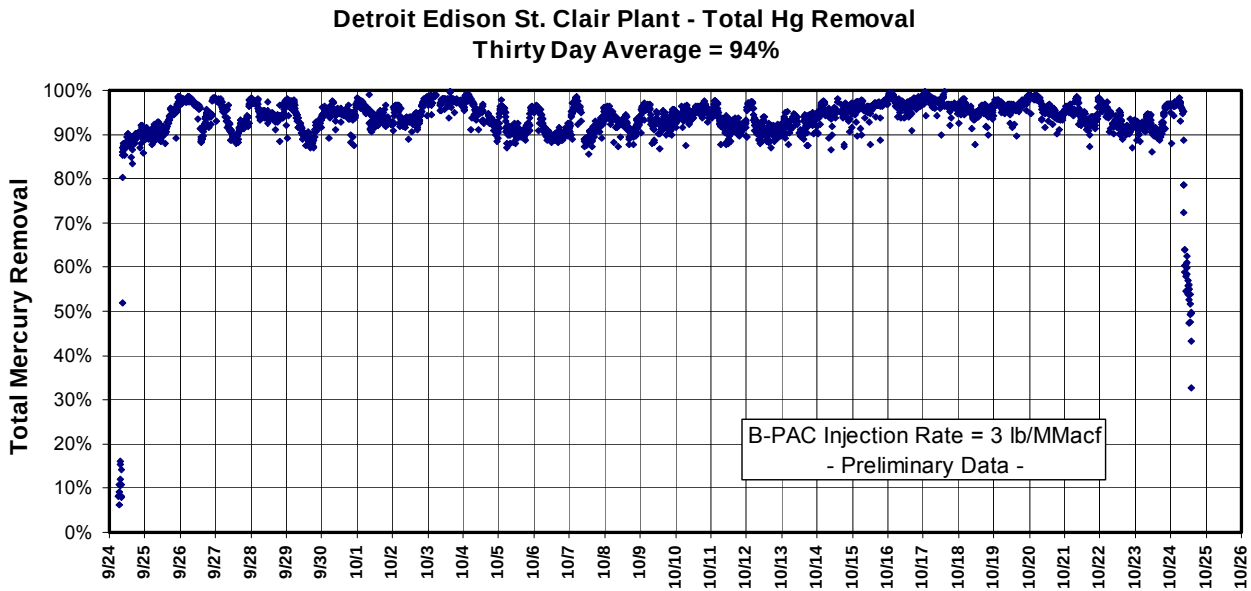
Advanced Utility Mercury Sorbent Field Testing -- *Sorbent Technologies*

- 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/10^6 ft^3 (48 kg/10^6 m^3)



Sorbent Injection for Small ESP Mercury Control
URS Group

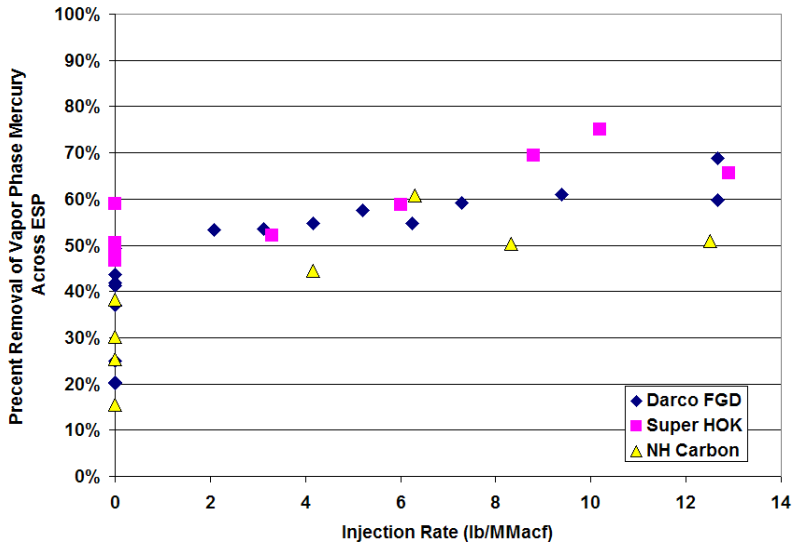
- Evaluate sorbents injected upstream of ESP with small specific collection area (SCA)

- 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

- Average baseline mercury removal ranged ~20-60%
- Short-term parametric testing w/ three conventional PACs: ~60% removal across ESP at 6 lb/10^6 ft^3 (96 kg/10^6 m^3)
  - Similar results on Unit 2
- Long-term testing w/ Super HOK
  - 60-85% removal across ESP at 4-10 lb/10^6 ft^3 (64-160 kg/10^6 m^3)
  - ESP outlet mercury emission rate ranged from 0.4 - 3.2 lb/TBtu (0.17 – 1.38 pg/J)
  - Increase in ESP power supply arcing rate
  - ~ 30% of particulate measurements exceeded baseline concentrations at ESP outlet



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

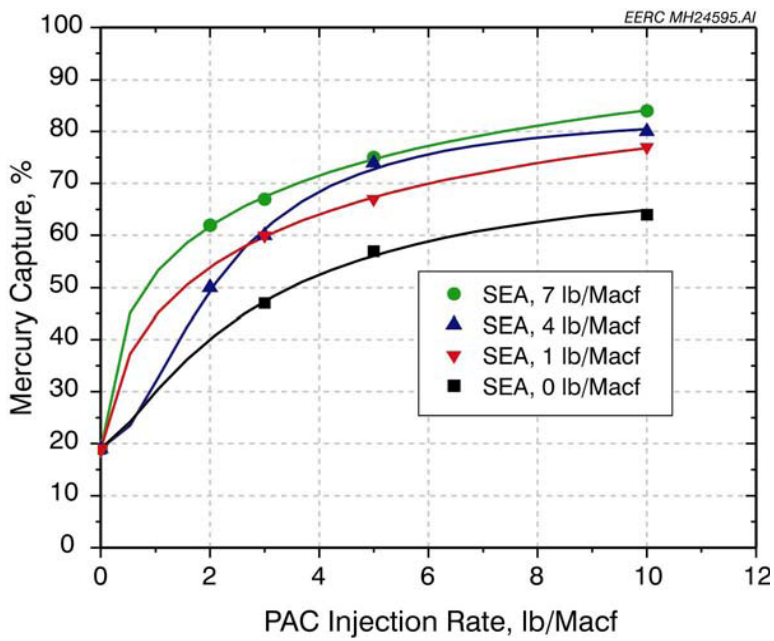
- Full-scale testing at four sites burning North Dakota lignite coal:
- ***Basin Electric's Leland Olds Station Unit 1***
  – equipped with ESP
- ***Basin Electric's Antelope Valley Station Unit 1***
  – equipped with SDA/FF
- ***Great River Energy's Stanton Station Unit 1***
  – equipped with ESP
- ***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/10^6 ft^3 (48 kg/10^6 m^3) sorbent injection (DARCO Hg)
- ESP outlet mercury emission rate averaged 2.04 lb/TBtu (0.88 pg/J)

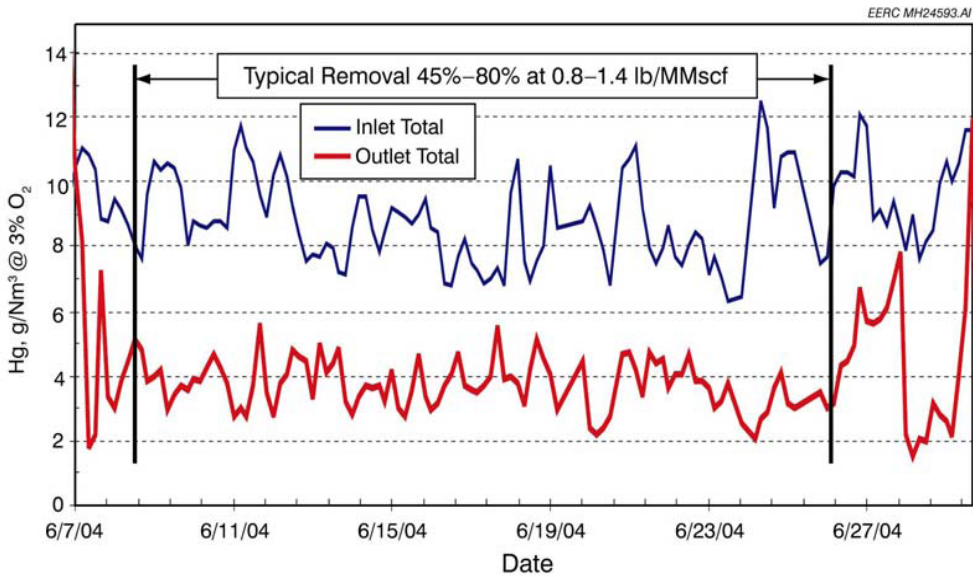
Parametric Test Results



Enhancing Carbon Reactivity in Mercury Control in Lignite-Fired Systems
Preliminary Results

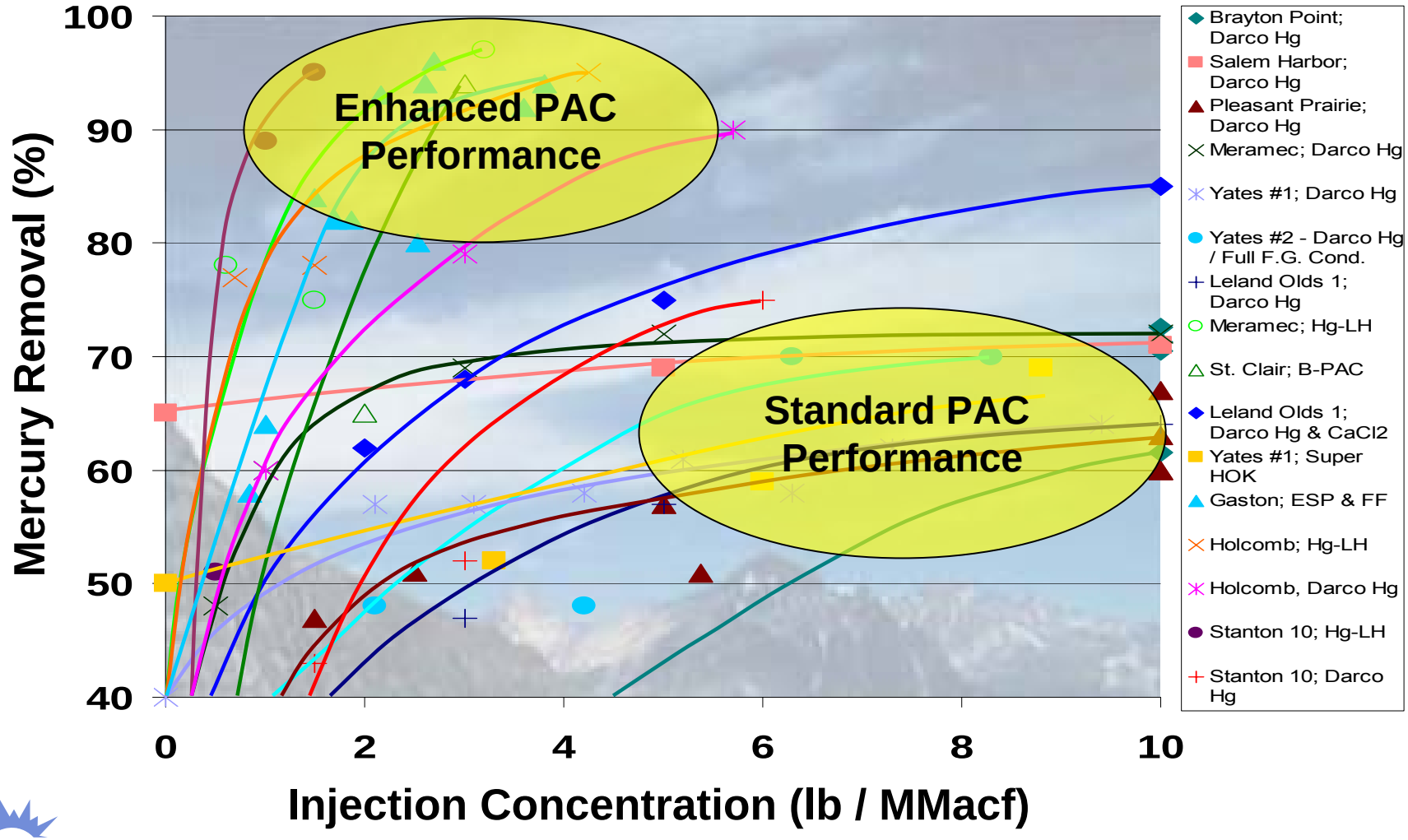
Great River Energy's 60 MW Stanton Station Unit 10

- Baseline mercury removal across SDA/FF <10%
- Mercury removal ranged from 45% to 80% (avg. 60%) during one-month long-term testing with halogenated activated carbon (DARCO Hg-LH) injection at 0.7 lb/10^6 ft^3 (11 kg/10^6 m^3)
- ESP outlet mercury emission rate ranged from 1.4 to 4.3 lb/TBtu (0.60 – 1.85 pg/J)



Field Testing Results 2001 – 2004

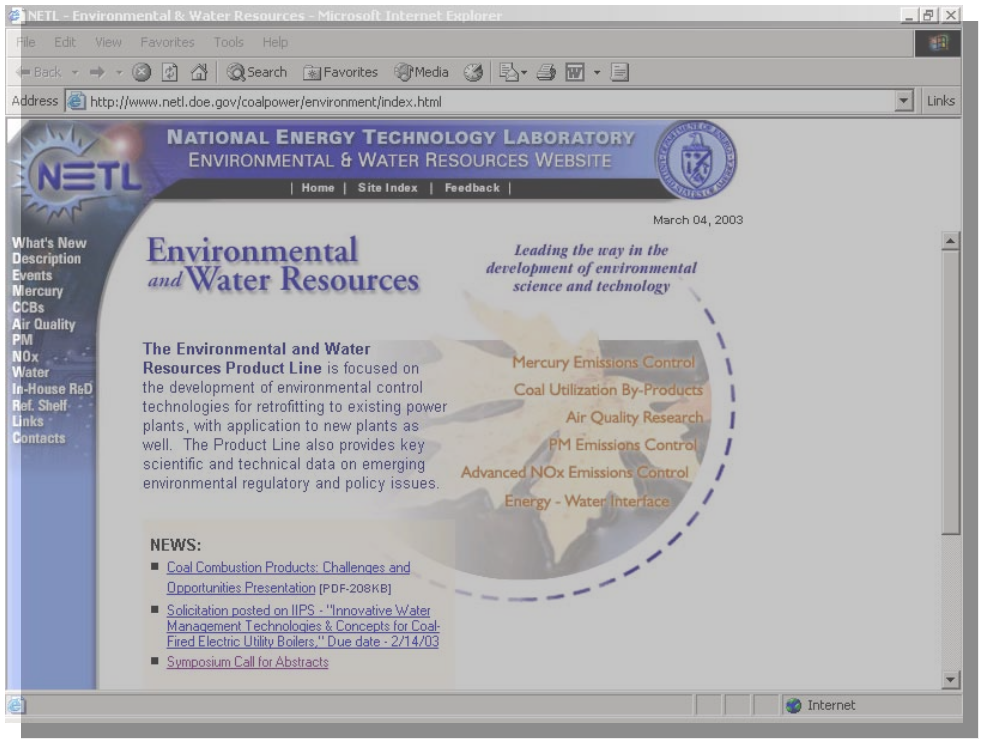
Comparison of Standard & Enhanced PAC



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**

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