

Mercury Reduction in Coal-Fired Power Plants: DOE's R&D Program



ARIPPA Technical Symposium

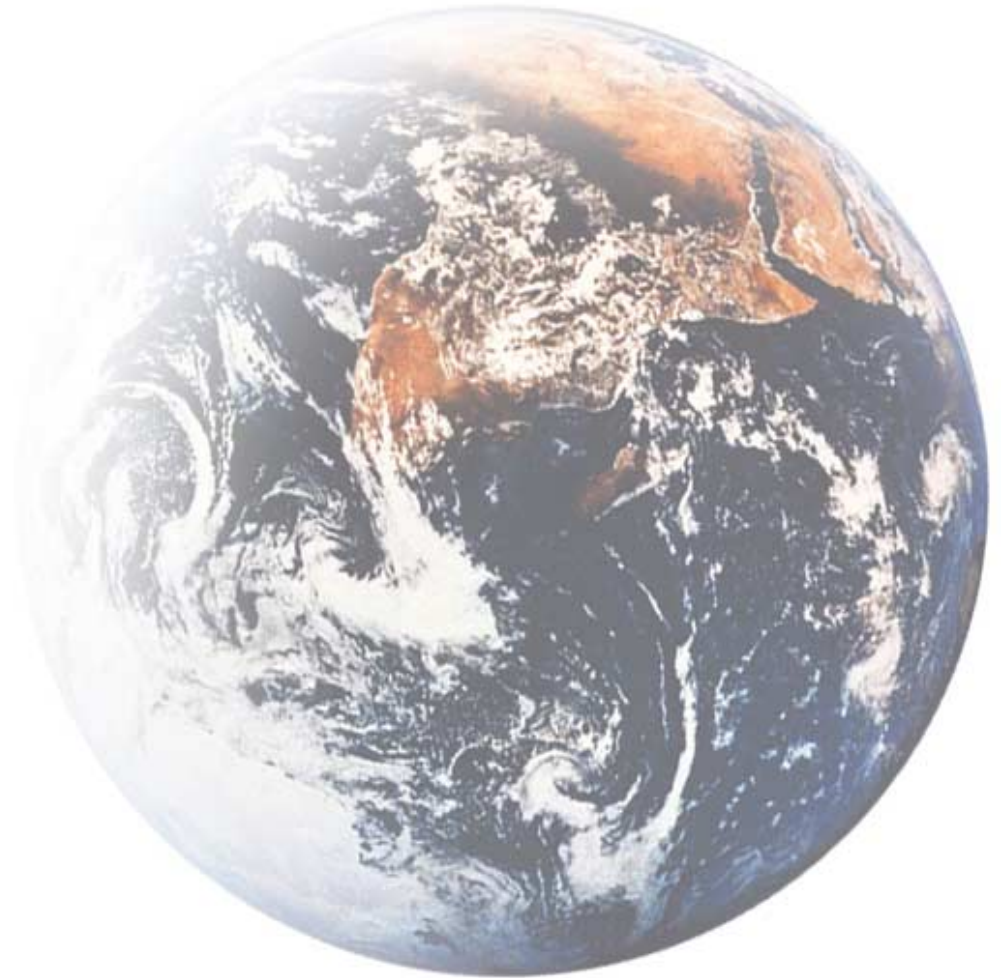
*August 21, 2002
State College, PA*

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Innovations for Existing Plants



Presentation Outline

- **About NETL**
- **IEP Program**
- **Hg Background**
- **Hg Control R&D**
- **Q&As**



About NETL



National Energy Technology Laboratory



- One of DOE's 17 national labs
- Government owned / operated
- Sites in:
 - Pennsylvania
 - West Virginia
 - Oklahoma
 - Alaska
- More than 1,100 federal and support contractor employees



NETL Plays Key Role in Fossil Energy Supply, Delivery, and Use Technologies

Electric Power Using Coal



Coal Production



Environmental Control



V21 Next Generation



Carbon Sequestration

Clean Liquid Fuels



Exploration & Production



Refining & Delivery



Alternative Fuels



Future Fuels

Natural Gas



Exploration & Production



Pipelines & Storage



Fuel Cells



Combustion Turbines



What We Do

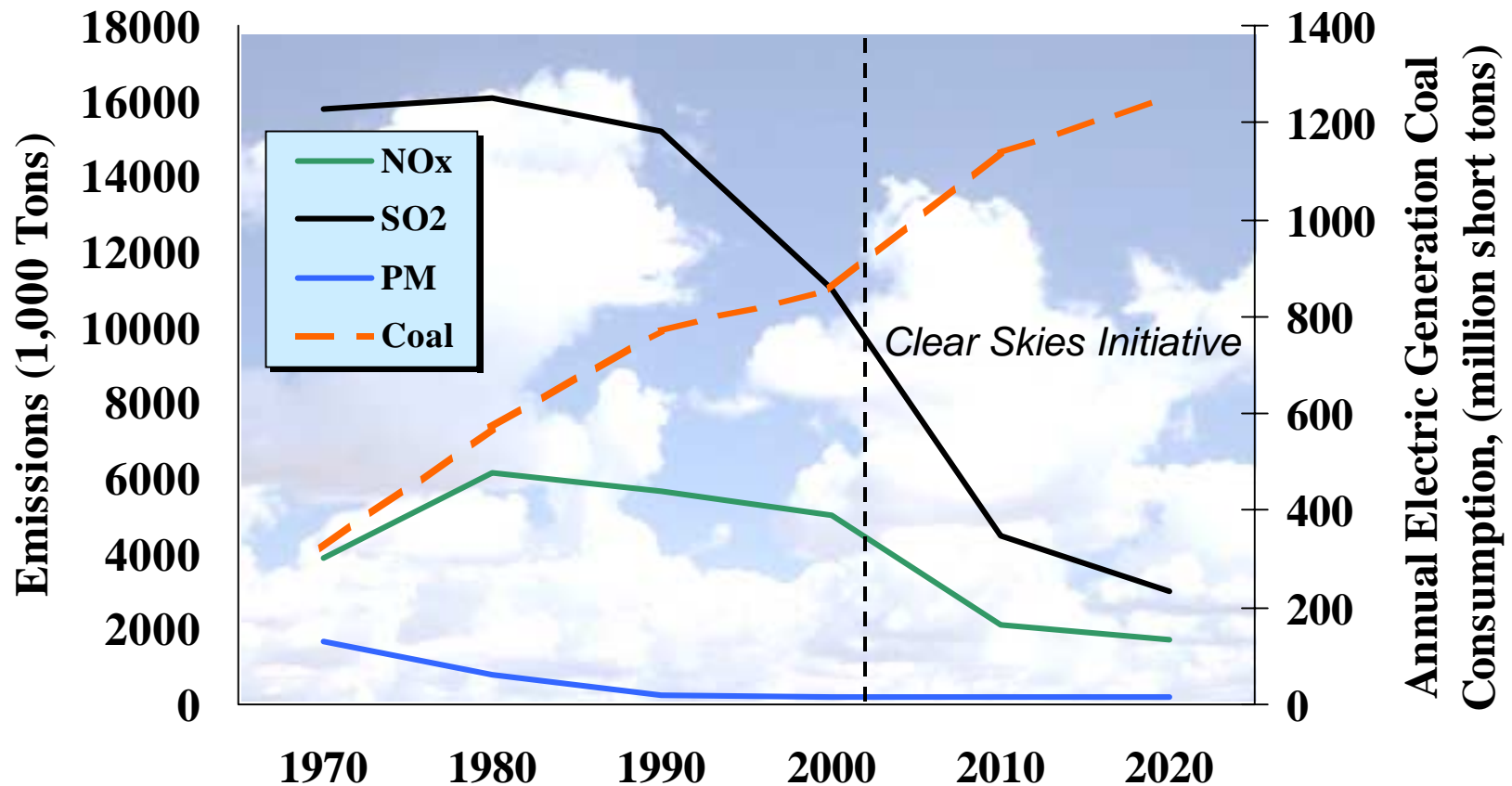
- Shape, fund, and manage extramural RD&D
- Conduct onsite research
- Support energy policy development



Innovations for Existing Plants



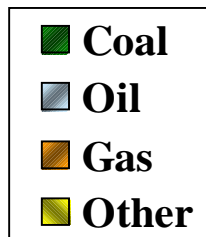
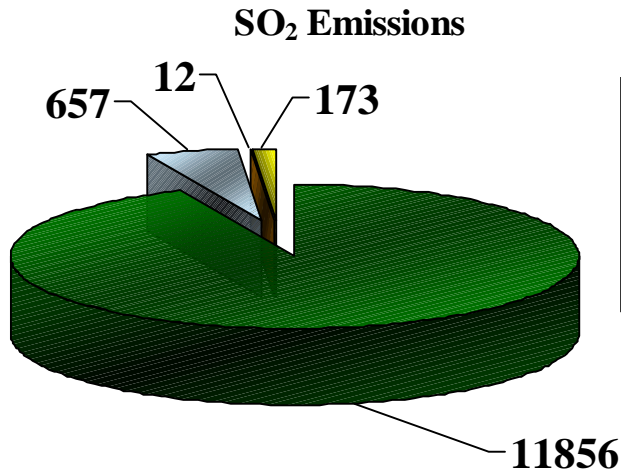
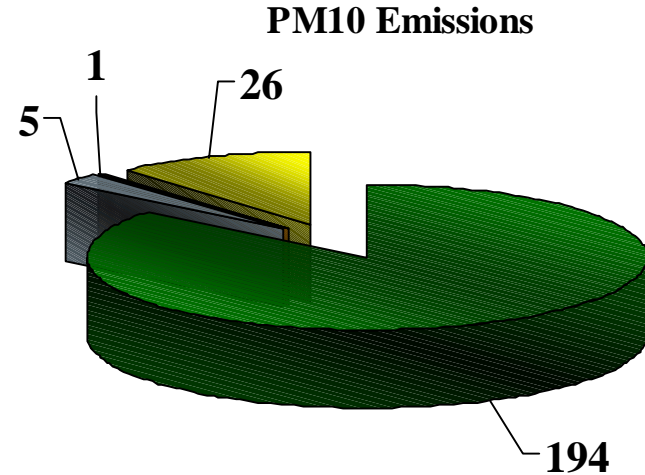
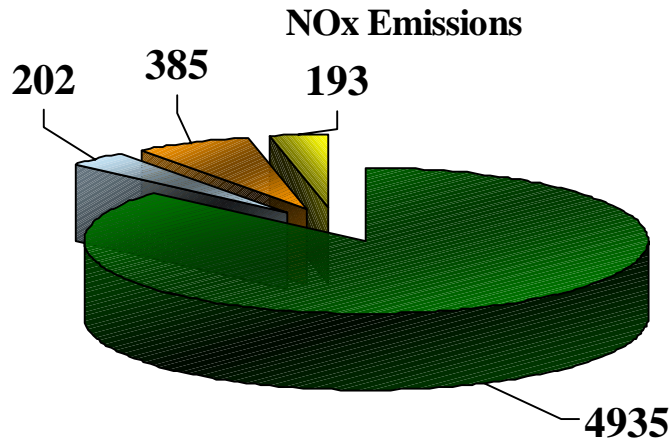
Continued Improvement in Environmental Performance of U.S. Power Plants



Source: U.S. EPA, "National Air Quality and Emissions Trends Report, 1999", Coal consumption projections based on EIA Reference Case from "Annual Energy Outlook 2002", and include all coal electric generation except cogenerators. Historical coal consumption from EIA "Annual Energy Review 2000" and includes only utility electric generation.



Electric-Utility Emissions by Fuel Type (thousand of short tons)



Coal's Contribution

- NO_x - 86%
- SO₂ - 93%
- PM10 - 86%

Source: EPA, "National Air Quality and Emissions Trends Report, 1999"

Environmental Drivers

- **Air**
 - PM2.5 NAAQS
 - Hg MACT determination
 - Multi-pollutant control
 - NOx SIP call
 - Regional haze rules
 - Acid gas emissions
- **Solids**
 - Coal byproducts utilization and disposal
- **Water**
 - Cooling water regulations
 - Air-water interface



Innovations for Existing Plants Program

- **Goal**

- Enhance environmental performance of existing fleet of coal power plants and advanced power systems

- **Objectives**

- Develop low-cost, integrated, non-complex technology to control emissions/releases (air, water, and solids) to the environment
- Provide high-quality scientific and technical information on environmental issues for use in future regulatory and policy decision making



IEP

Technical Performance Specs

- ≤ 0.15 lb/mmBtu NO_x
- **50-70% mercury capture (2005); +90% capture (2010)**
- **99.99% removal of particulate matter**
- **95% acid gas capture**



*Mercury Sorbent Injection
Ports at Southern Company's
Gaston Station*

Strategic Importance

- **Clear Skies Initiative**

- On February 14, 2002 President Bush announced a plan to significantly reduce emissions of SO₂, NO_x, and mercury from power plants employing a market-driven, phased-in strategy

- **National Energy Policy**

- Chapter 3, “*Protecting America’s Environment*,” of May 2001 NEP calls for the federal government to facilitate energy development while simultaneously protecting environment



Mercury: Background Information



Mercury

Why is there a Concern?



Mercury Can Bio-accumulate in Aquatic Foodchain

- Mercury is a neurotoxin
- Mercury can bio-accumulate in aquatic foodchain
- 12/00 EPA determination of “plausible link” between power plants and environmental mercury

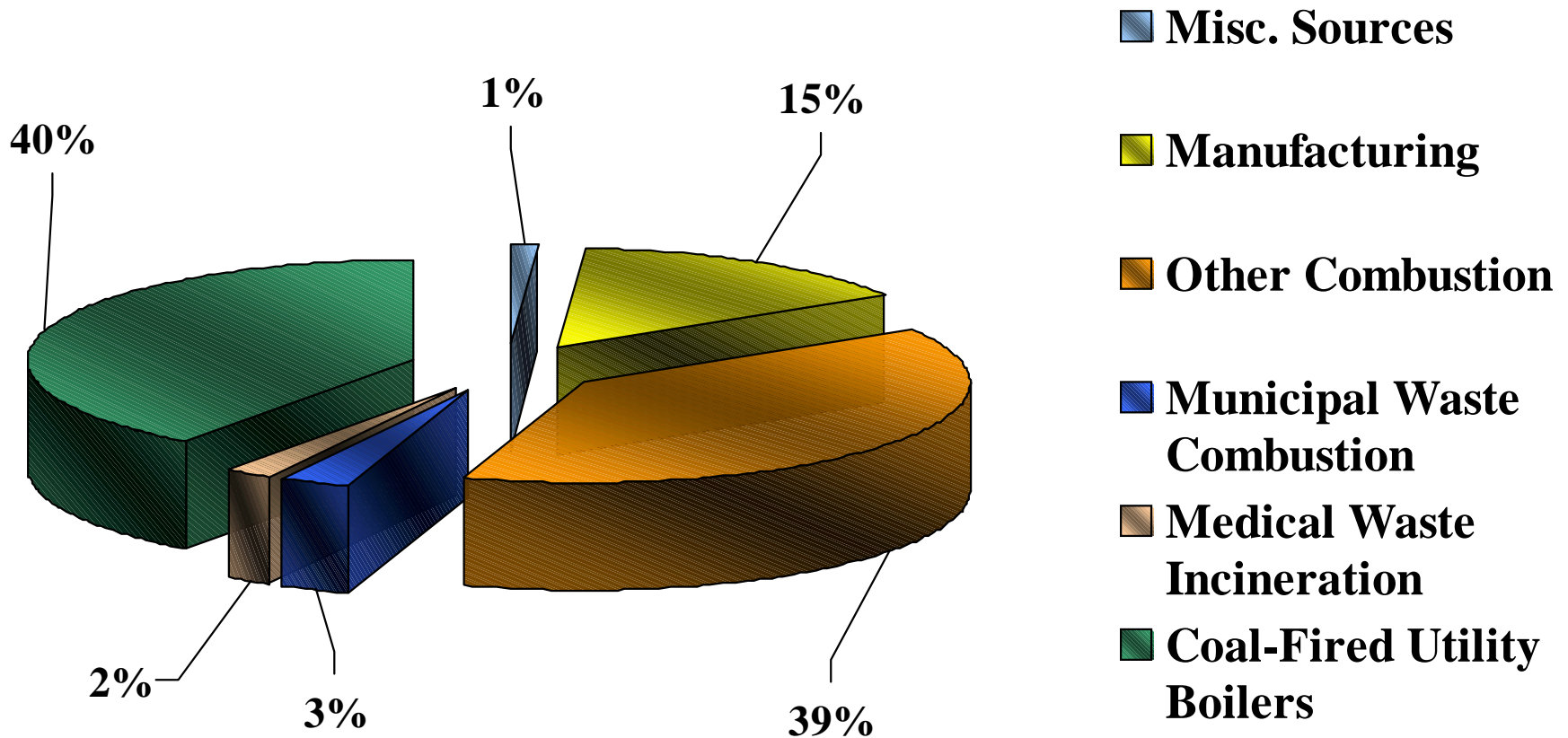
Mercury in Coal



- **Coal has very little mercury**
 - Coal: 10-100 ppb
 - Earth's crust: 80 ppb
 - Fluorescent light bulb: 175 ppm
 - Thermometer: 10,000 ppm
- **Utility industry burns a lot of coal**

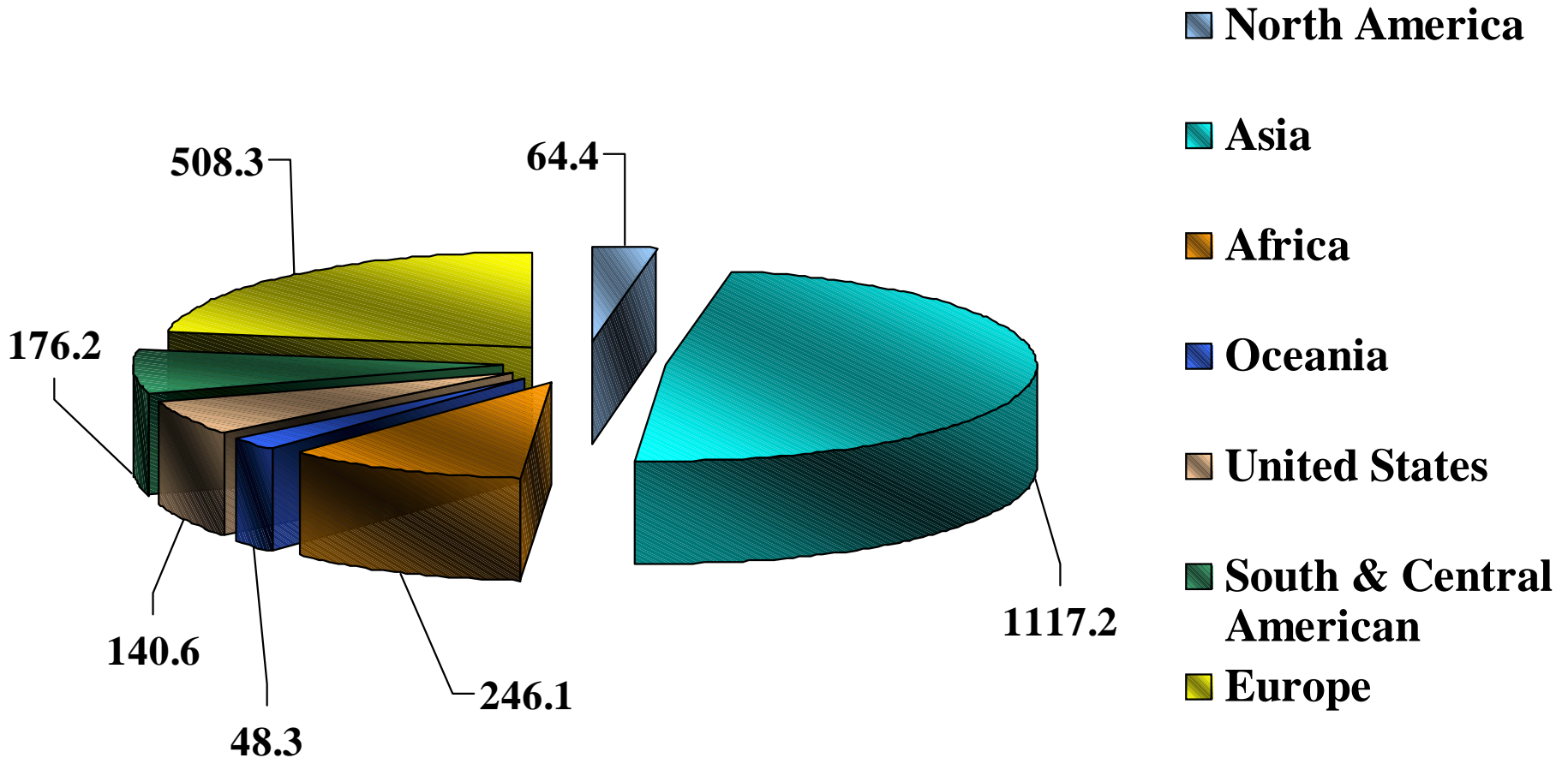
Source: Larry Monroe, Southern Company Services, July 10, 2002, Washington Coal Club

Current U.S. Mercury Emissions by Source Category



Coal-fired utility boilers emitted 48 tons of mercury in 1999 based on EPA ICR data

Global Mercury Emissions (Mg/yr)



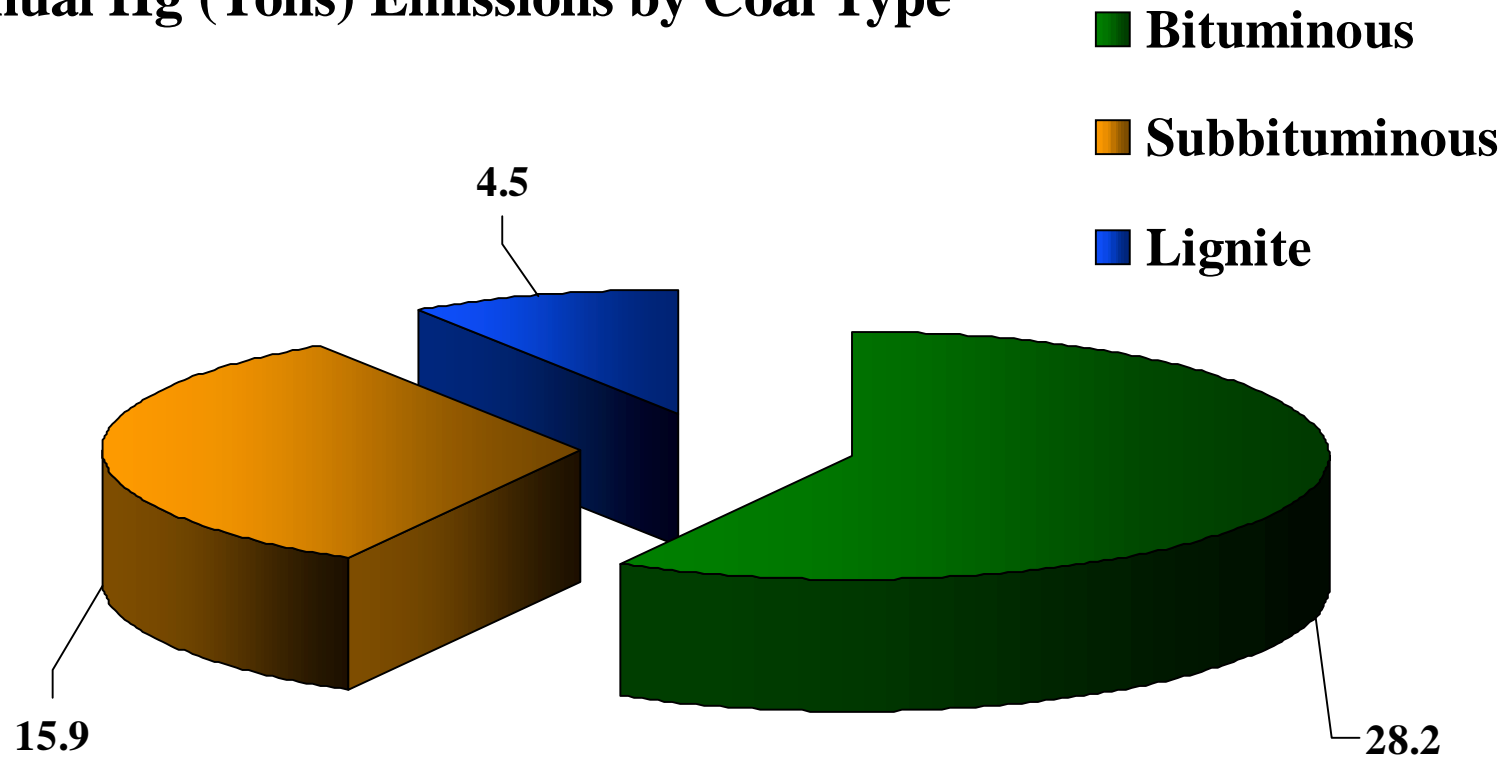
U.S. coal-fired power plants contribute about 2% of annual global Hg emissions

Source: EPRI



Hg Emissions by Coal Type

Annual Hg (Tons) Emissions by Coal Type



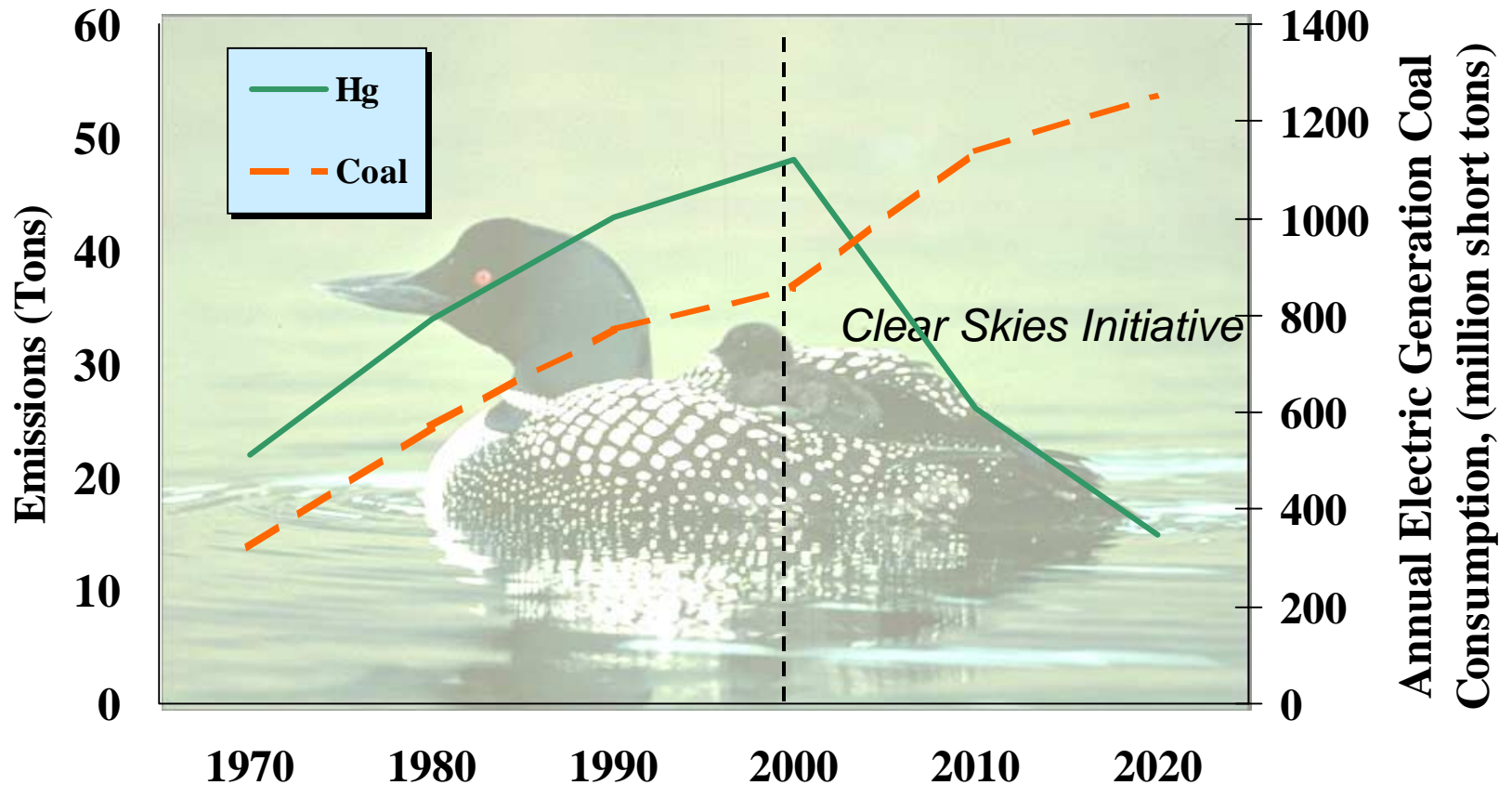
Total Hg Emissions: 48 tons/year



Mercury Control R&D



CSI - Continuing to Improve Environmental Performance of Coal-Based Power Plants



Source: Coal consumption projections based on EIA Reference Case from "Annual Energy Outlook 2002", and include all coal electric generation except cogenerators. Historical coal consumption from EIA "Annual Energy Review 2000" and includes only utility electric generation.

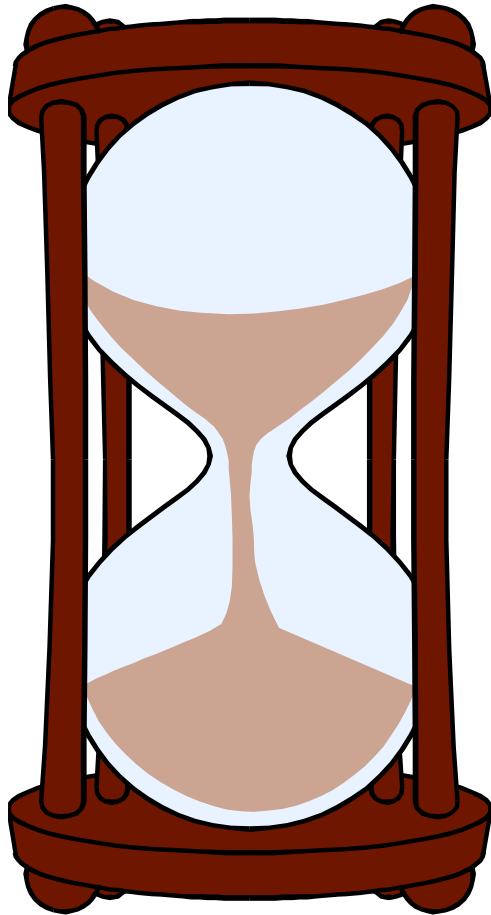
Proposed Emissions Reductions

Electric Power Plants

			Clear Skies		Jeffords
<i>Emission</i>	<i>Actual 1999</i>	<i>Baseline</i>	<i>2008/2010 Cap</i>	<i>2018 Cap</i>	<i>2007 Cap</i>
SO₂	12.0 M tons/yr	8.9 M tons/yr	4.5 M tons/yr	3.0 M tons/yr	2.2 M tons/yr
NO_x	7.1 M tons/yr	4.0 M tons/yr	2.1 M tons/yr	1.7 M tons/yr	1.5 M tons/yr
Mercury	48 tons/yr	48 tons/yr	26 tons/yr	15 tons/yr	4.8 tons/yr
CO₂	2.19 B tons/yr	?	None	None	1.94 B tons/yr



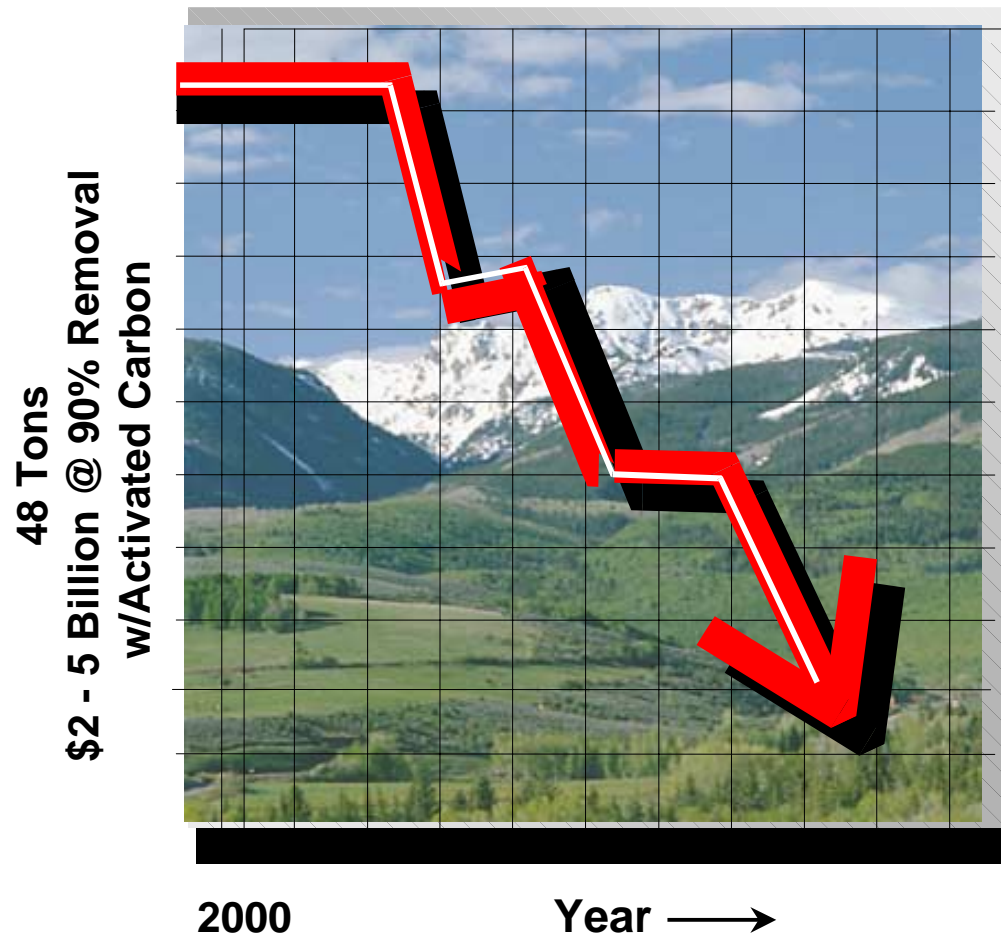
EPA's Maximum Achievable Control Technology (MACT) Process



- Dec. 2000 - EPA determined need to regulate Hg from power plants
- Dec. 31, 2003 - Propose utility Hg regulations
- Dec. 31, 2004 - Promulgate final Hg regulations
- December 31, 2007 - Full industry compliance

Mercury Control

- Have technologies ready for commercial demonstration:
 - By 2005, reduce emissions 50-70%
 - By 2010, reduce emissions by 90%
 - Cost 25-50% less than current estimates



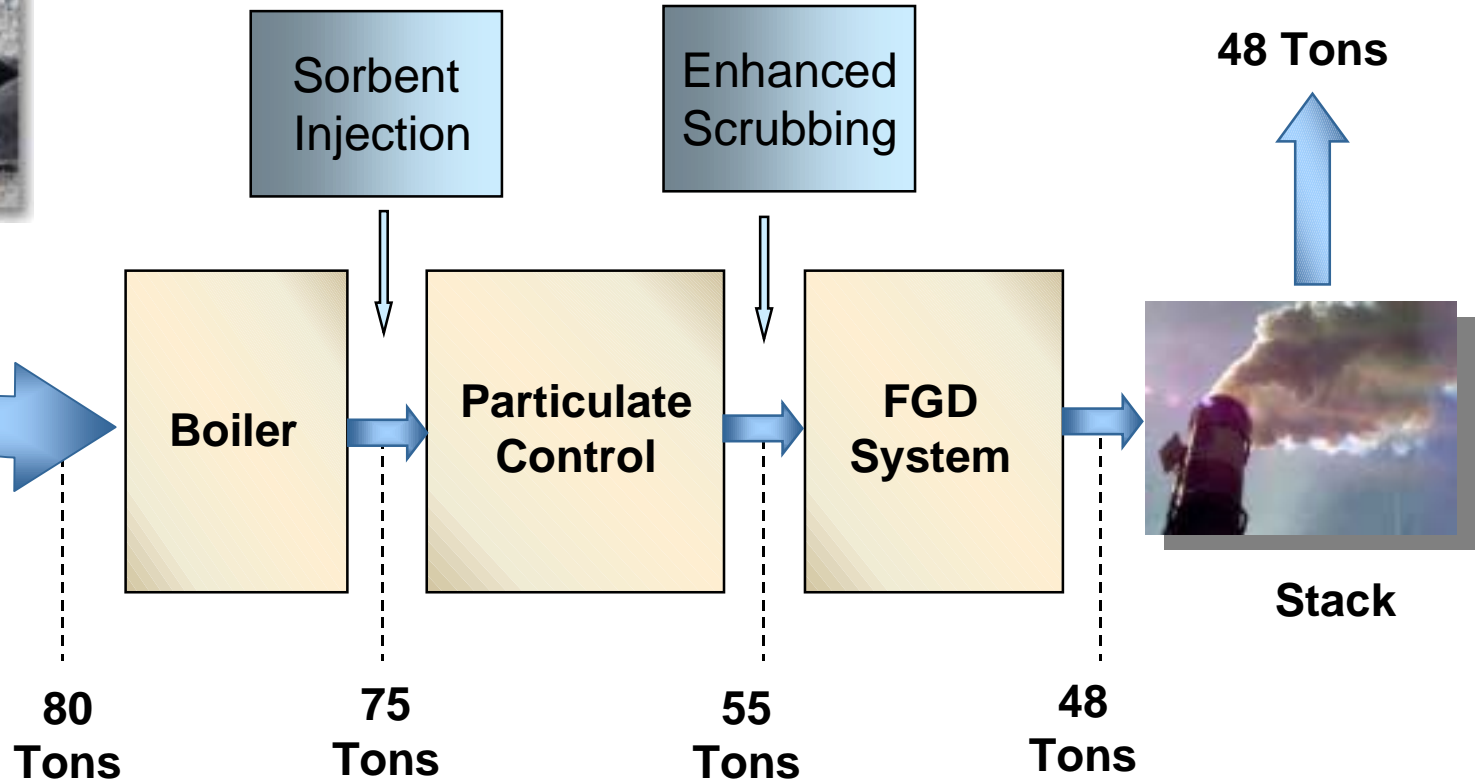
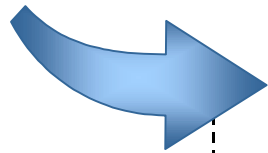
Baseline costs: \$30,000 - \$70,000 per lb. Hg removed



Mercury Partitioning Across a Power Plant



After Coal
Cleaning



Hg Field Test Schedule

<i>Technology/Utility-Plant</i>	<i>Testing Date</i>
<i>ADA-ES – Sorbent Injection</i>	
<i>Alabama Power - Gaston</i>	March-April, 2001
<i>WEPCO - Pleasant Prairie</i>	September-November, 2001
<i>PG&E – Salem Harbor</i>	June-July, 2002
<i>PG&E – Brayton Point</i>	October-November, 2002
<i>McDermott-B&W – Enhanced Scrubbing</i>	
<i>Michigan South Central Power- Endicott</i>	May-June, 2001
<i>Cinergy -- Zimmer</i>	October-December, 2001



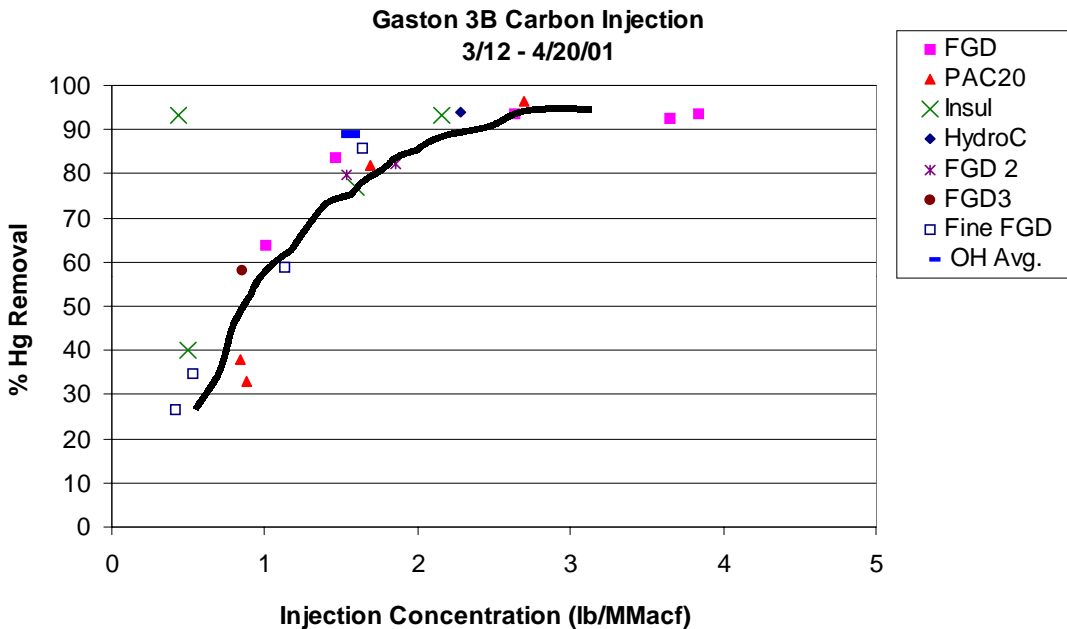
Capturing Mercury in Coal-Fired Power Plant is Difficult!



Houston AstroDome

- Mercury is present in flue gas at concentrations of about 1 part-per-billion
- Equivalent to 30 black ping pong balls in Houston AstroDome filled with 30 billion ping-pong balls
- 90% mercury capture would require finding and removing 27 of 30 black ping-pong balls

Hg Field Testing Southern Company Gaston Station



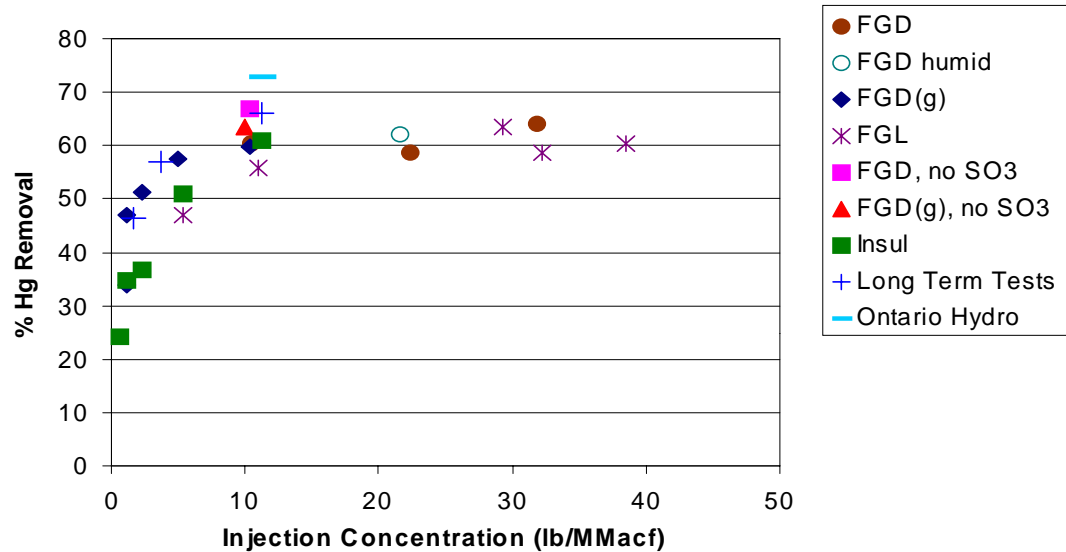
78% Average Total Mercury Removal

- Tested in Spring 2001
- Bituminous coal
- Hot-side ESP and COHPAC fabric filter
- Injection concentration ~1.5 lb/MMacf



Hg Field Testing WEPCo's Pleasant Prairie Station

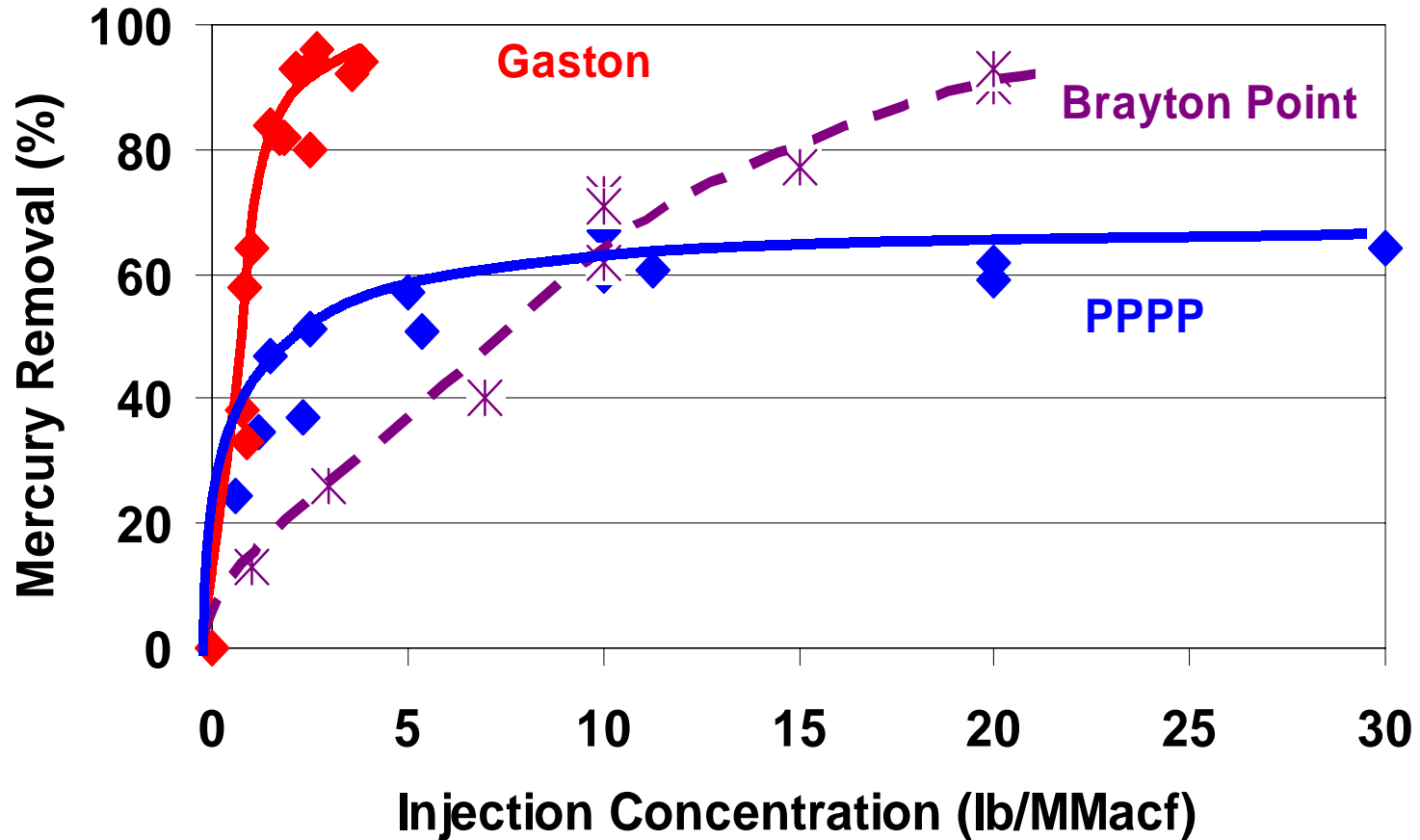
- Tested Fall 2001
- PRB coal
- Cold-side ESP
- Injection concentration of ~10lb/MMacf
- Negative impact on sale of fly ash



73% Average Total Mercury Removal



Mercury Removal Trends with ACI



Hg Field Testing

Preliminary Observations



***Sorbent Injection System
at WEPCo Pleasant
Prairie Station***

- Initial field testing results promising
- Important balance-of-plant issues raised that will need to be addressed
- Further field testing needed on a broader spectrum of coals and power plant configurations

Advanced Hg Control Concepts

- **University of North Dakota Energy & Environmental Research Center**
 - Hybrid particulate control system
- **URS Group**
 - Catalyst to convert elemental to oxidized Hg
- **CONSOL**
 - Multi-pollutant control technology to remove Hg, SO₂, and acid gases
- **Southern Research Institute**
 - Calcium-based additives for controlling mercury
- **Powerspan Corp.**
 - Multi-pollutant control technology to remove Hg, SO₂, NO_x, particulates, and acid gases
- **Apogee Scientific**
 - Advanced mercury sorbents

Designed to Achieve \geq 90% Hg Removal



UNDEERC

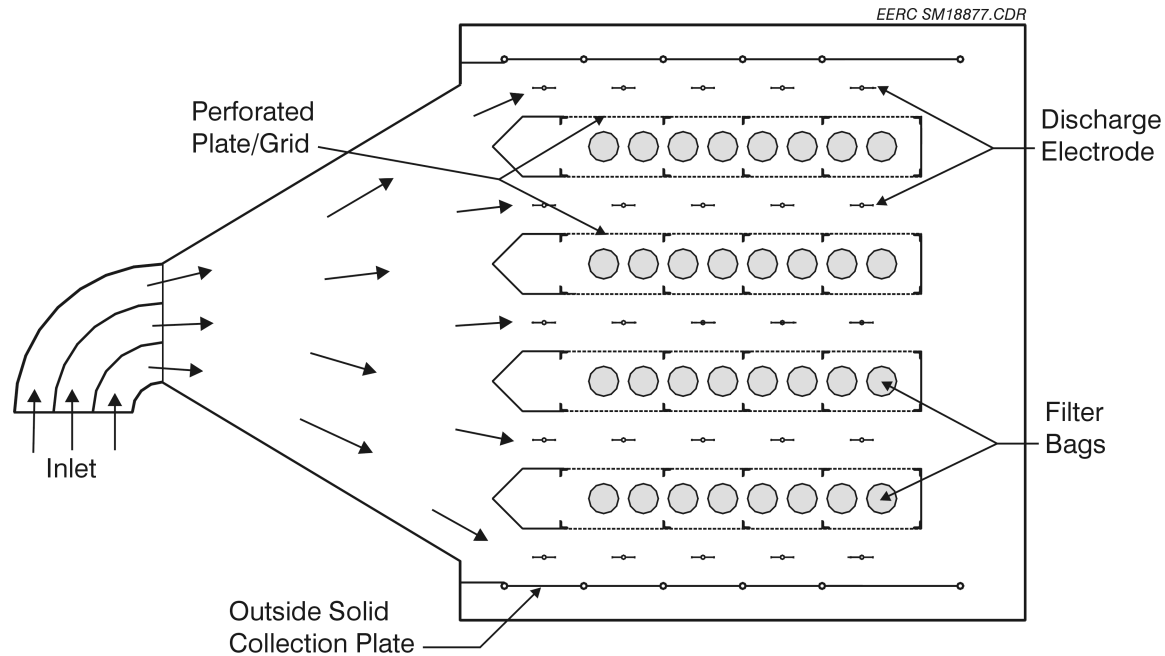
Advanced Hybrid Particulate Collector

- **Evaluate sorbent injection:**
 - pulse-jet baghouse
 - advanced hybrid particulate collector (AHPC)
- **200 acfm pilot-scale testing**
 - subbituminous and high-sulfur eastern bituminous coal
- **9,000 acfm slipstream testing at Otter Tail Power**
 - PRB coal with variable sorbent residence times
 - 3 month testing for mercury removals



*AHPC Slipstream Test Unit
at Big Stone Power Plant*

AHPC Design Configuration



- ~ 90% of particles collected on ESP plates
- Less frequent bag cleanings = longer bag life

URS

Catalytic Mercury Oxidation

- **Develop catalyst to oxidize Hg upstream of wet FGD**
- **Slip-stream testing at two utility sites to determine quantities needed for high oxidation efficiency (>90%) and catalyst life at pilot scales**
- **Great River Energy burning ND lignite w/ESP & Wet Scrubber**
 - Coal Creek Station (unit 1 or 2) - North Dakota
- **City Public Service of San Antonio**
 - J.K. Spruce Plant
 - Subbituminous coal



URS

Pilot Unit Design

- Located between particulate controls and FGD on host plant
- Evaluate four catalysts in parallel for 14 months/site
- Each catalyst chamber 1 meter x 1 meter
- Treated flue gas flow rate is equivalent to 2.5 MW



URS Pilot-Scale Catalyst Unit

Mercury and Coal Byproducts



FGD Byproduct Material

- **Multi-pollutant legislation could significantly impact coal utilization byproducts (CUBs):**
 - increase volume of CUBs
 - potentially effect reuse and disposal
- **If regulated as hazardous material, could cost industry \$14 billion/year**

Coal Utilization Byproducts (CUB) R&D

- Characterize leaching and volatilization of Hg and other metals
- Evaluate CUB reuse applications
- Develop separation technologies



*Artist Rendition of
Vision21 Power Plant*

Further Research Needed

- **Longer term field testing of mercury control technologies**
- **Continued development of advanced concepts**
- **Investigation of impacts on coal byproduct use and disposal**
- **Implications of global emissions on U.S.**
- **Improvements in CEMs**



Future Plans

- **Issue a competitive solicitation in early FY03 to conduct a second phase of Hg control technology field testing**
- **Working with stakeholders to craft scope of solicitation regarding:**
 - Coal types to be evaluated
 - Plant size and configuration, including downstream control equipment
 - Length of testing
 - Application of Hg CEMs



Future Plans (cont.)



*Mercury Wet Deposition Monitor
near Holbrook, Greene County, PA*

- Continue development of novel concepts capable of 90%+ Hg removal
- Investigate mercury emission, transport (e.g., plume chemistry), and deposition

Future Plans (cont.)

- **Expand characterization of CUBs collected from mercury control technology field testing**
- **Continue development of fly ash-carbon separation technologies**



Partnership is Key to Success!

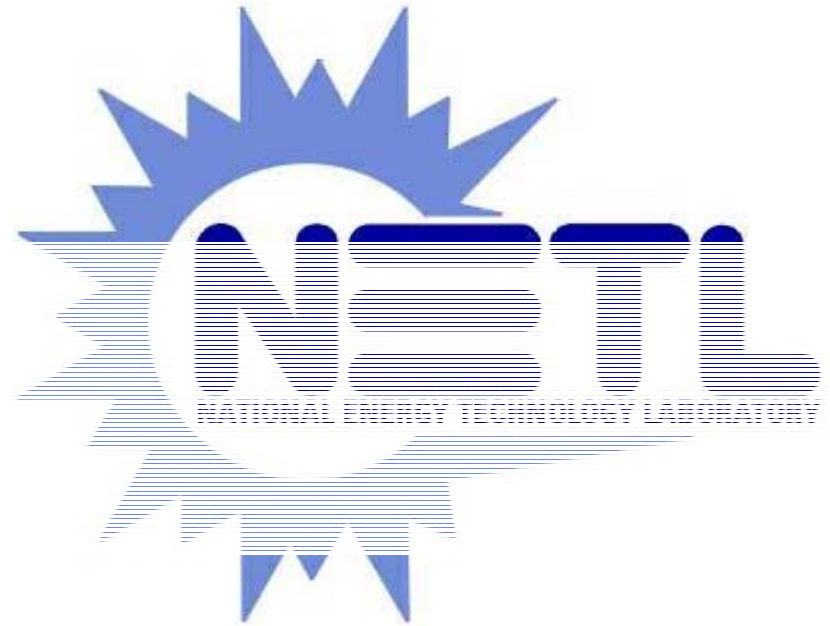


Jim Kilgroe (EPA), Scott Renninger (NETL), and George Offen (EPRI), and Larry Monroe (SCS) discussing mercury control field testing plans



For More Information...

- Visit IEP website at:



www.netl.doe.gov/coalpower/environment

