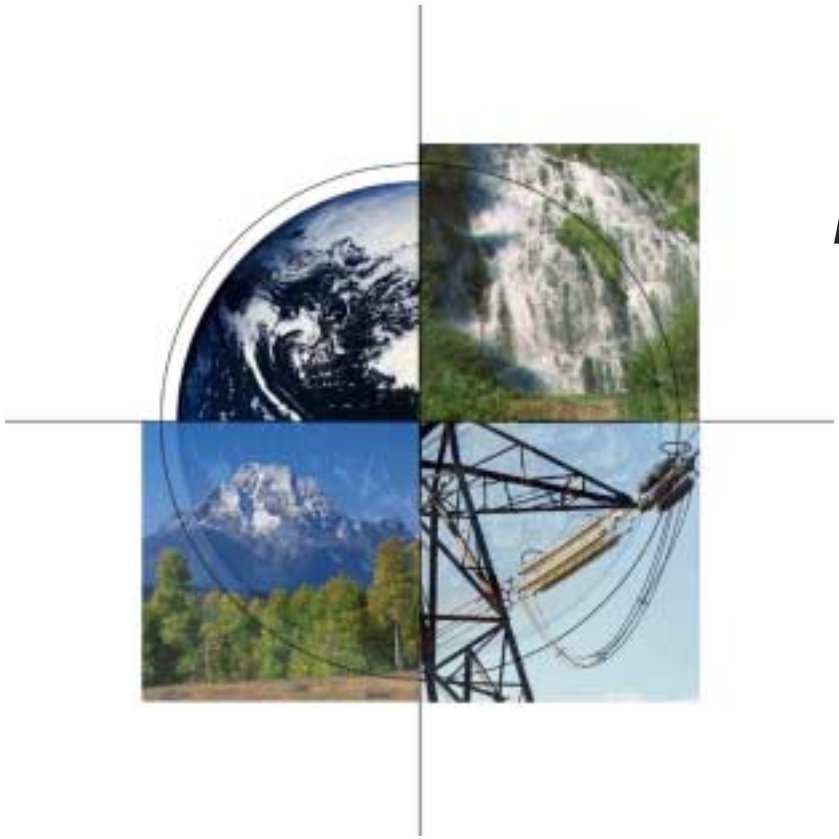
# DOE/NETL's Mercury Emissions Control Technology R&D Program



## *LRC and Lignite Industry Meeting*

***August 27-28, 2002***

***Bismarck, ND***

Thomas J. Feeley, III, Product Manager
Innovations for Existing Plants

# Presentation Outline

- About NETL
- IEP Program
- Hg Background
- Hg and lignite coals
- Hg Control R&D

# 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**

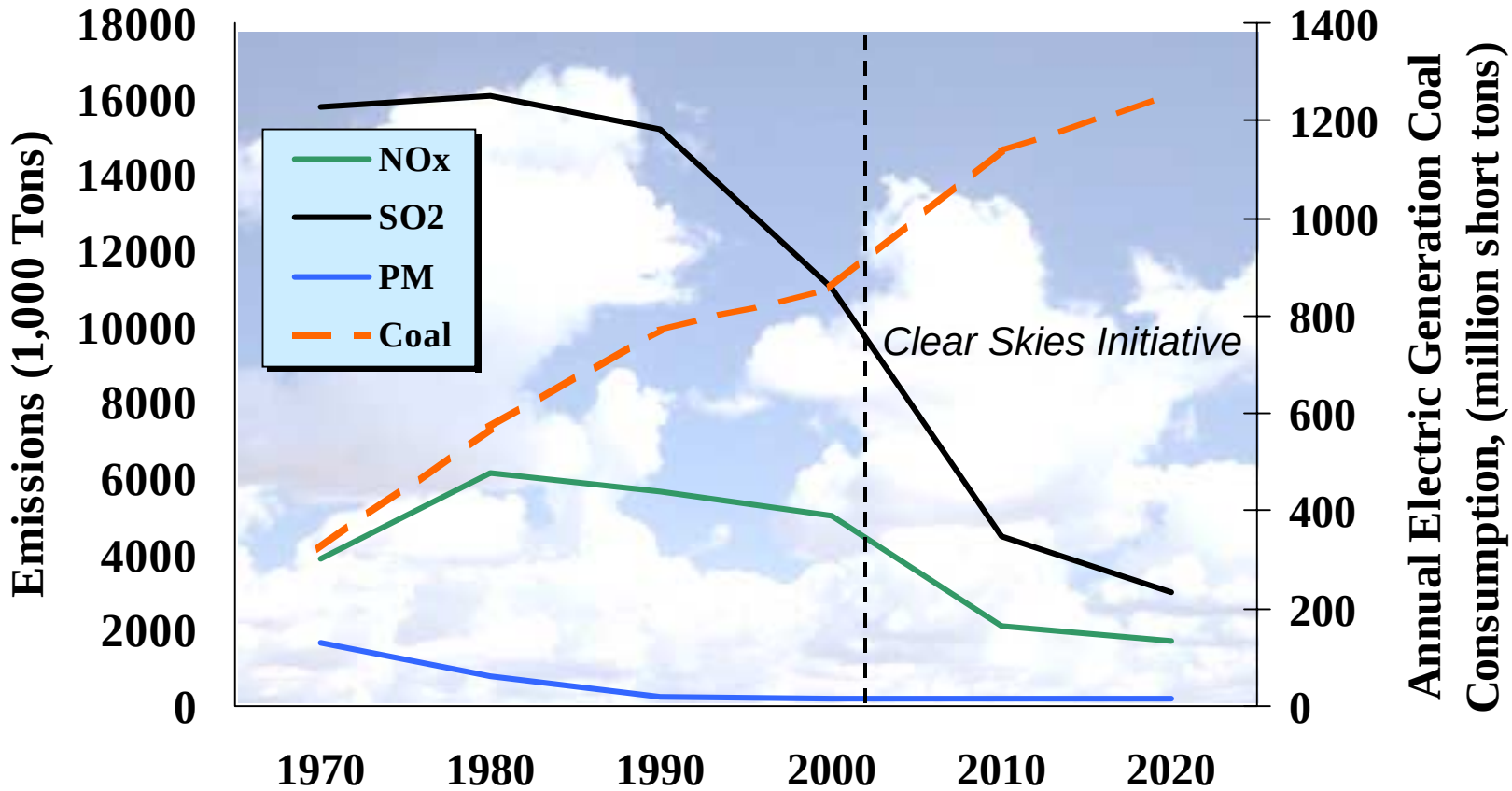
*Photo of hydrogen fueled car: Warren Gretz, NREL*

# What We Do

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

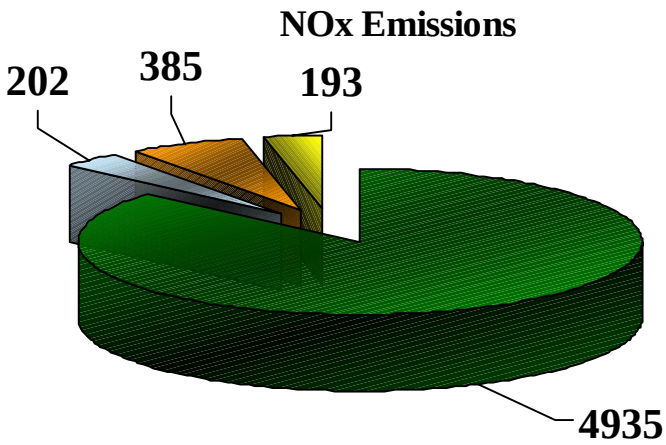
# Innovations for Existing Plants

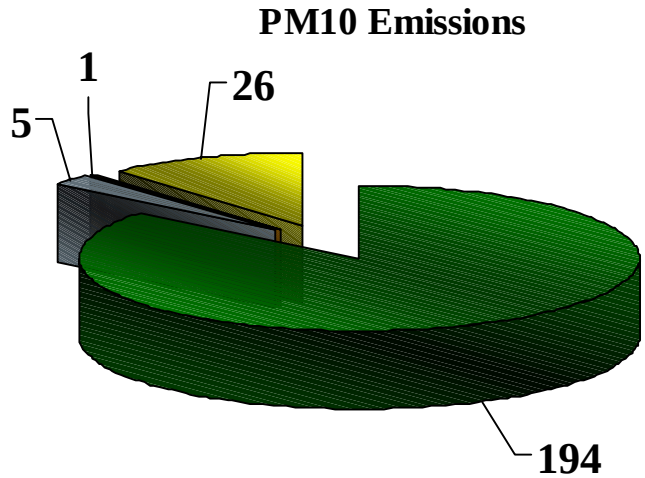
# Continued Improvement in Environmental Performance of U.S. Power Plants

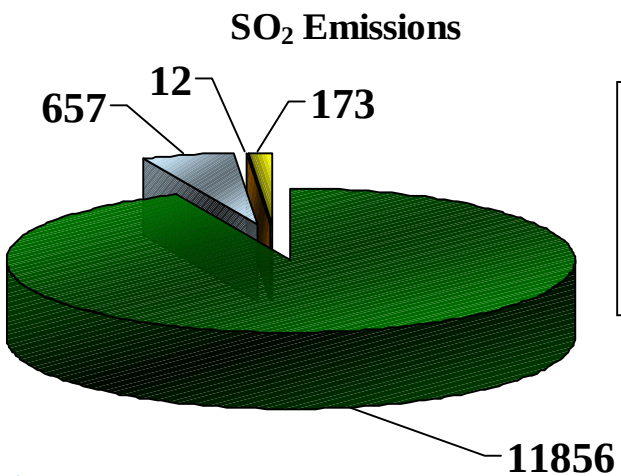


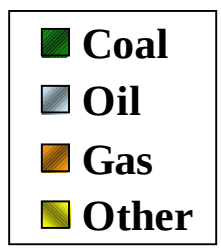

Source: U.S. EPA, "National Air Quality and Emissions Trends Report, 1999", Coal consumption projections based on EIA Reference Case from "Annual Energy Outlook 2002", and include all coal electric generation except cogenerators. Historical coal consumption from EIA "Annual Energy Review 2000" and includes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

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




***Coal's Contribution***

- NOx - 86%
- $SO_2$ - 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 NOx
- **50-70% mercury capture (2005); +90% capture (2010)**
- 99.99% removal of particulate matter
- 95% acid gas capture

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

# Strategic Importance

- **Clear Skies Initiative**
  - On February 14, 2002 President Bush announced a plan to significantly reduce emissions of $SO_2$, NOx, 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***

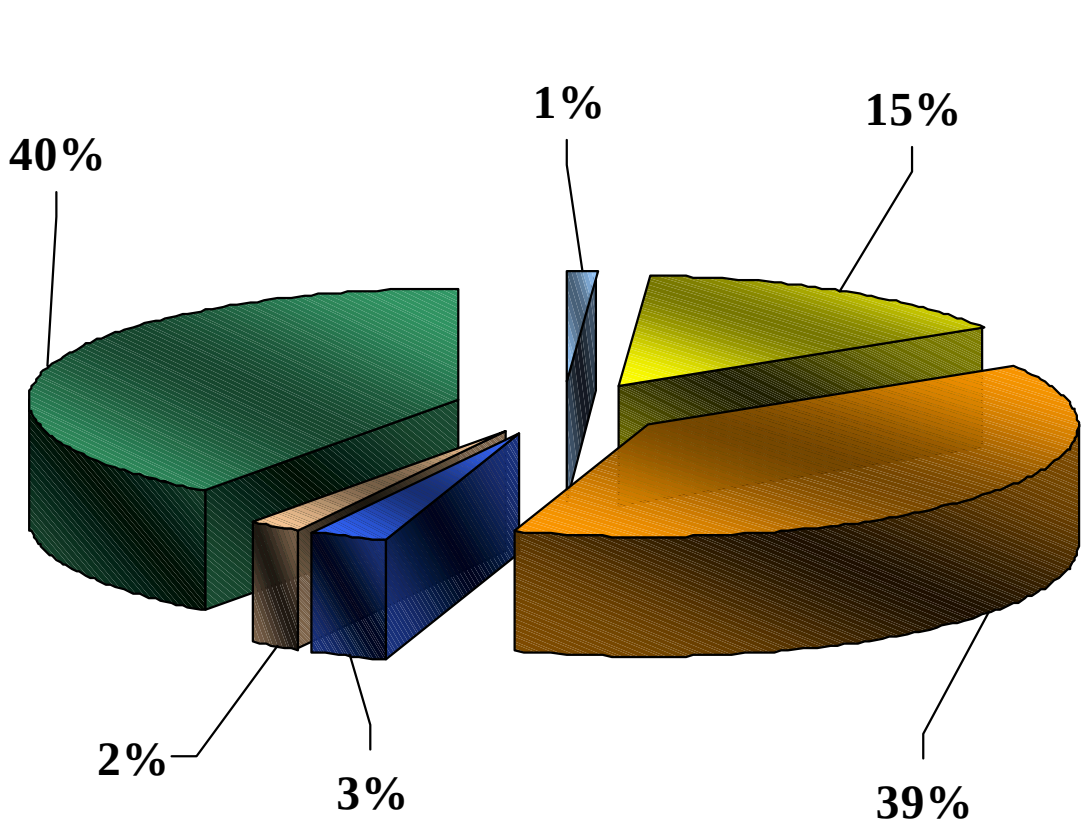
- **Mercury is a neurotoxin**
- **Mercury can bio-accumulate in aquatic foodchain**
- **12/00 EPA determination of “plausible link” between power plants and environmental mercury**

# 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

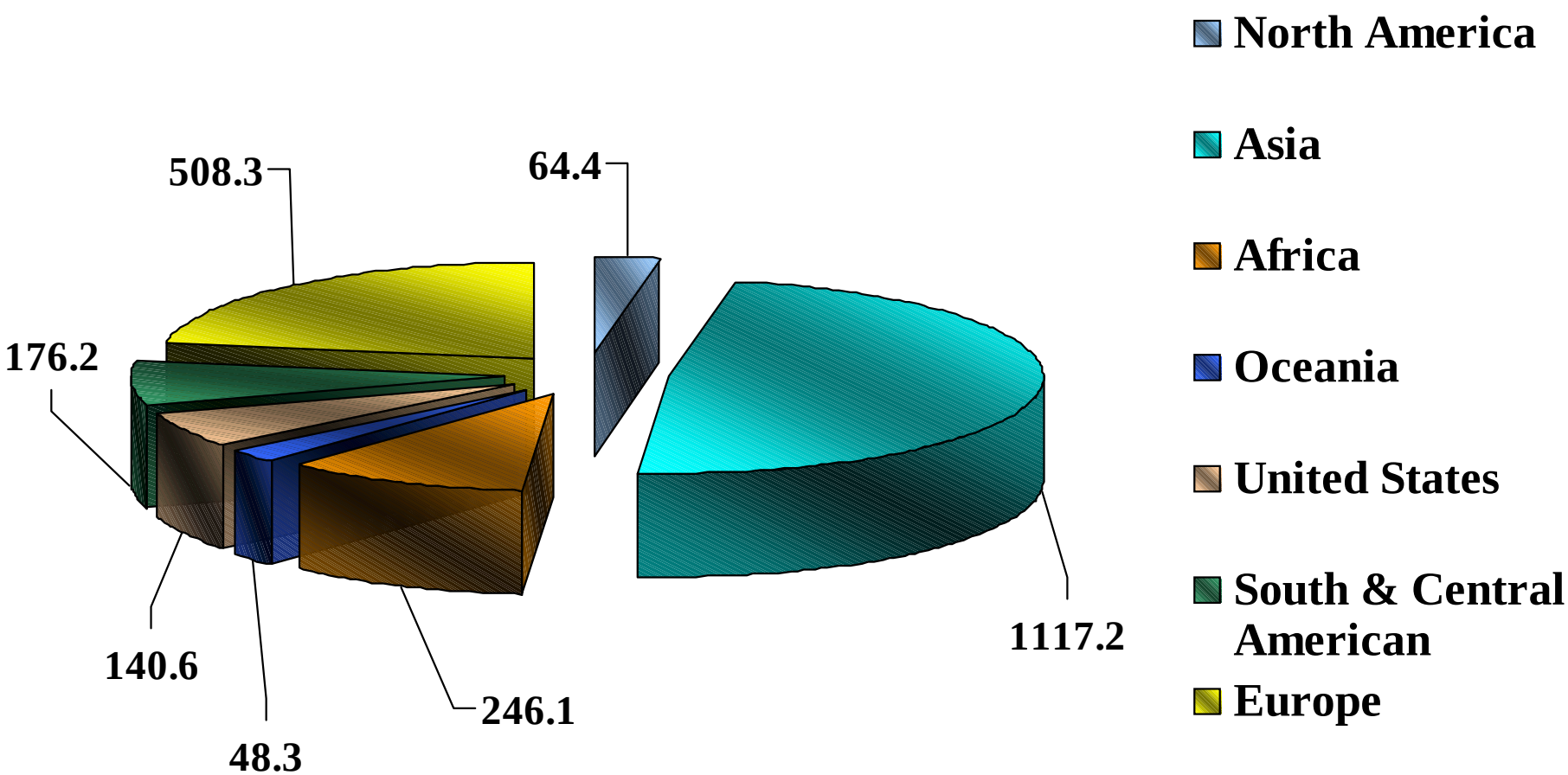
# Current U.S. Mercury Emissions by Source Category




- Misc. Sources
- Manufacturing
- Other Combustion
- Municipal Waste Combustion
- Medical Waste Incineration
- Coal-Fired Utility Boilers

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

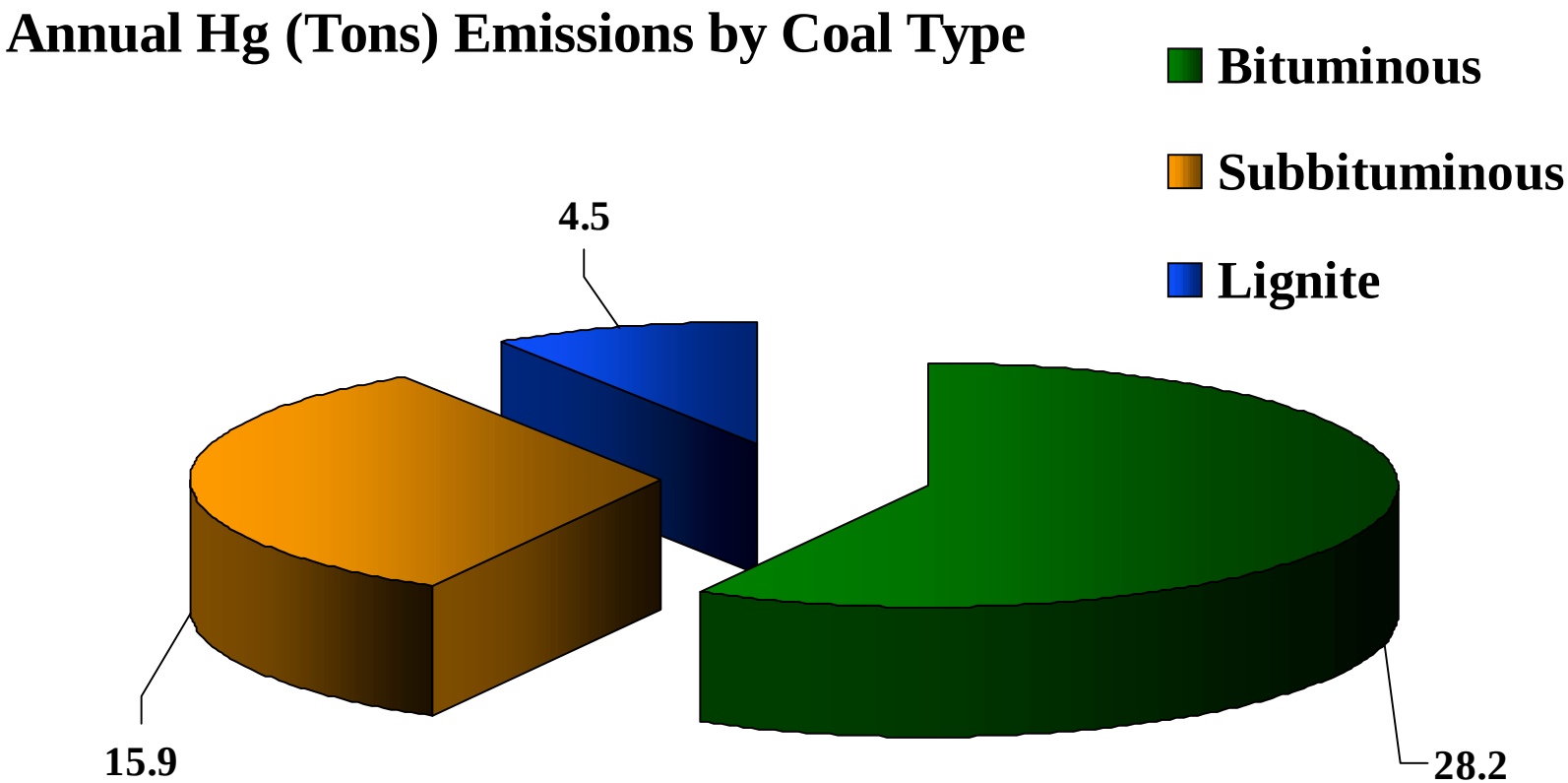
# Global Mercury Emissions (Mg/yr)




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

Source: EPRI

# Hg Emissions by Coal Type




**Total Hg Emissions: 48 tons/year**

# 1999 ICR Data Relevant to Lignite

- **Contribution of lignite to total coal burned for electricity generation:**
  - 17 electric utility power plants burned lignite
  - All facilities located near lignite mines in North Dakota, Texas, Louisiana, and Montana
  - Total of 51 million tons burned
  - 6.5% by wt. of all coal burned by electric utilities

*Source: Kilgroe, J.D., et al, "Control of Mercury Emissions from Coal-Fired Electric Utility Boilers: Interim Report," USEPA, April 2002.*

# Lignite Hg More Difficult to Capture

- **Hg more difficult to capture in existing control technology due to:**
  - Lower HCl in flue gas
  - Higher alkalinity of fly ash
- **Lignite flue gas tends to have lower $Hg^{++}/Hg^{0}$ ratio**
- **Fly ash less likely to promote oxidation of Hg**

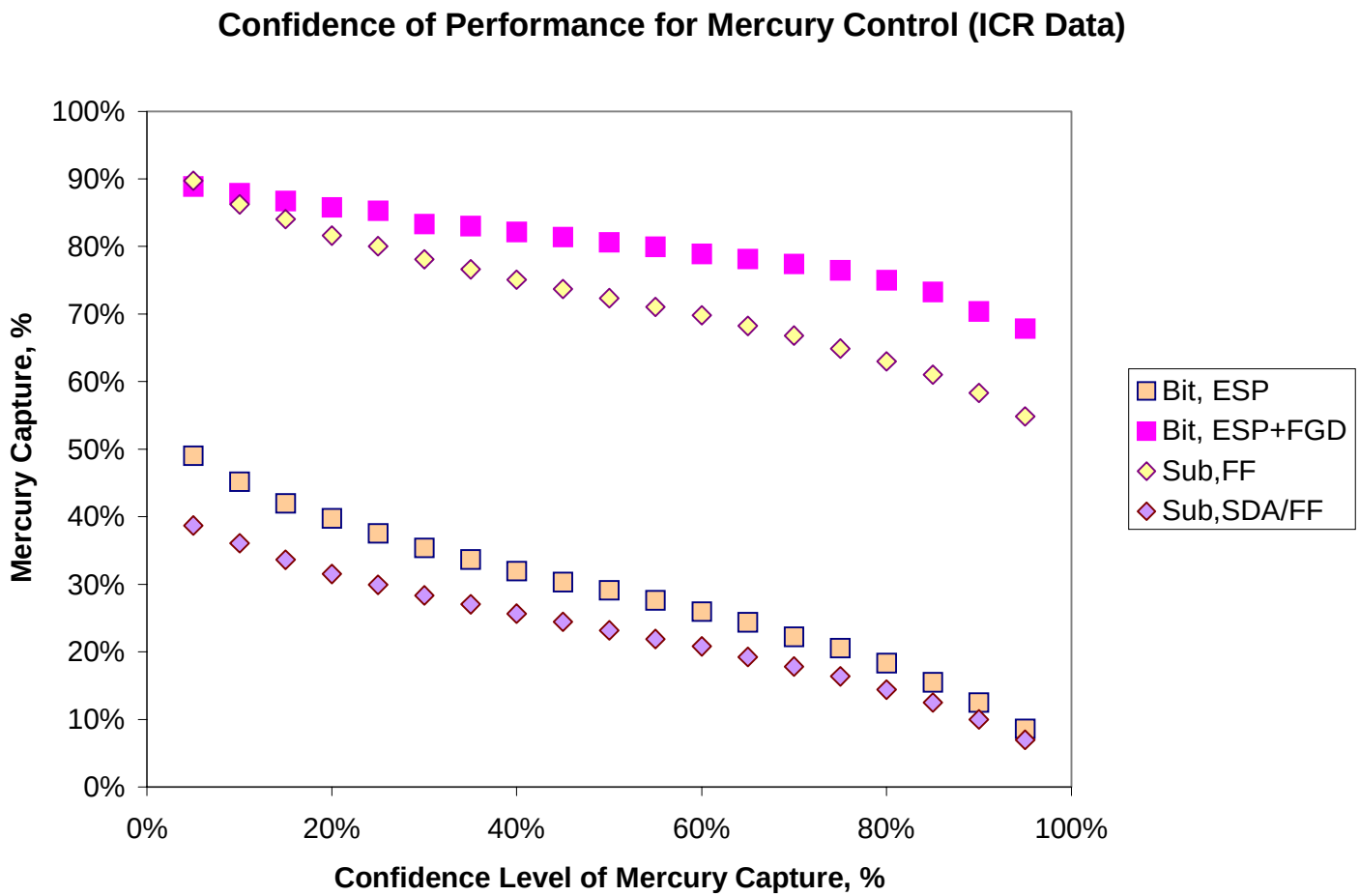
# 1999 ICR Hg Control Data for Lignite-Fired Power Plants

| | | Average Hg Emission Reduction (%) | | | |
|---|---|---|---|---|---|
| | | | | Lignite | |
| | | Bituminous | Sub-bituminous | % Red. | # of Units |
| **Post Combustion Emission Controls** | | | | | |
| **PM Control Only** | CS-ESP | 36% | | (4%) | 1 |
| | CS-ESP + FF | Not tested | Not tested | (15%) | 2 |
| **PM Control and Spray Dryer Absorber** | SDA + FF | 98% | 24% | 0% | 2 |
| **PM Control and Wet FGD System** | PS + FGD | 12% | (8%) | 33% | 1 |
| | CS-ESP + FGD | 75% | 29% | 44% | 2 |

13 lignite-fired units (8 PC-boilers, 3 cyclone boilers, and 2 FBC units)

Source: Kilgroe, J.D., et al, "Control of Mercury Emissions from Coal-Fired Electric Utility Boilers: Interim Report," USEPA, April 2002.

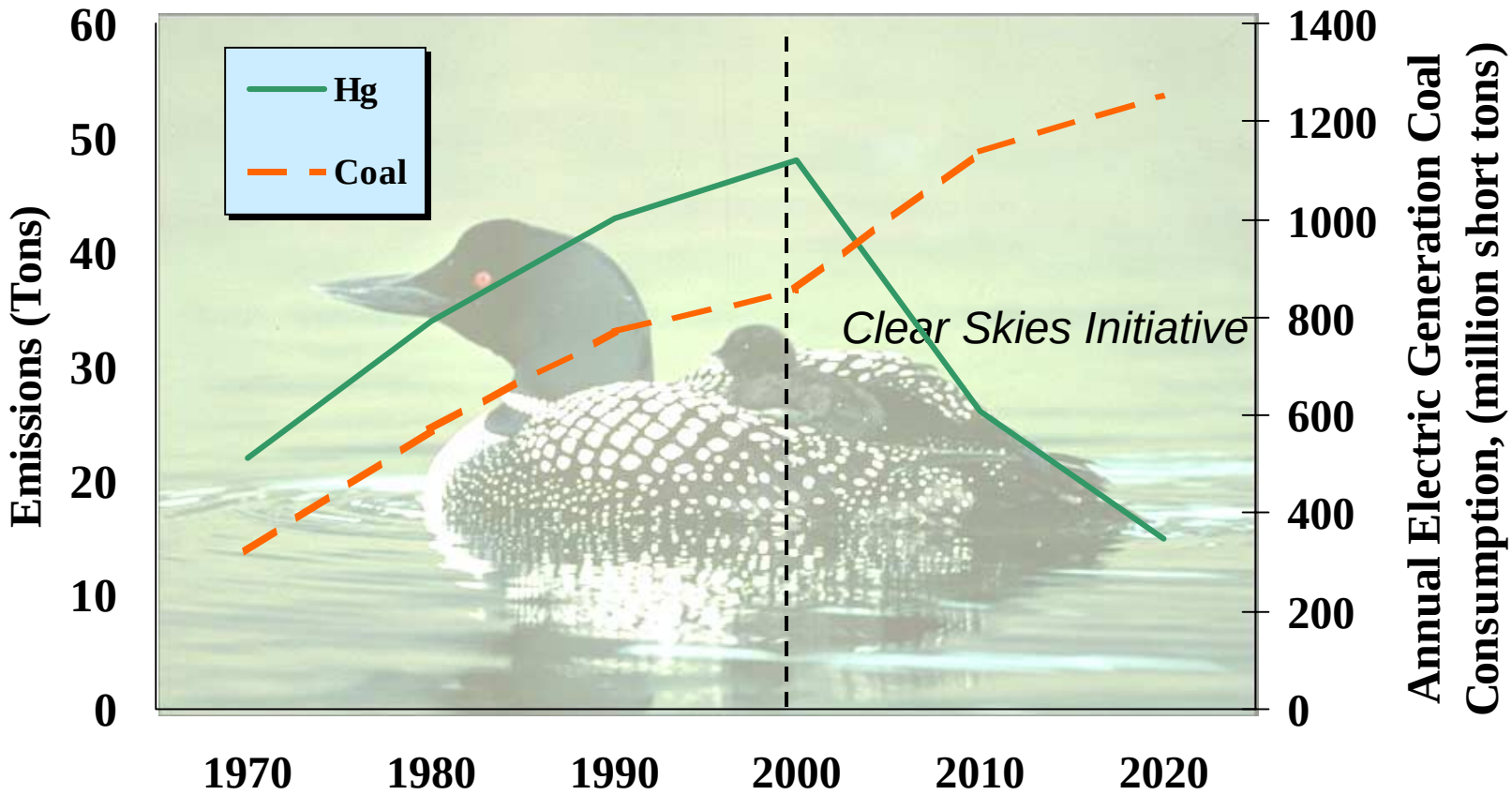
# ICR Data Uncertainty




Source: D. Smith, DOE/NETL, 08/02.

# Mercury Control R&D

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



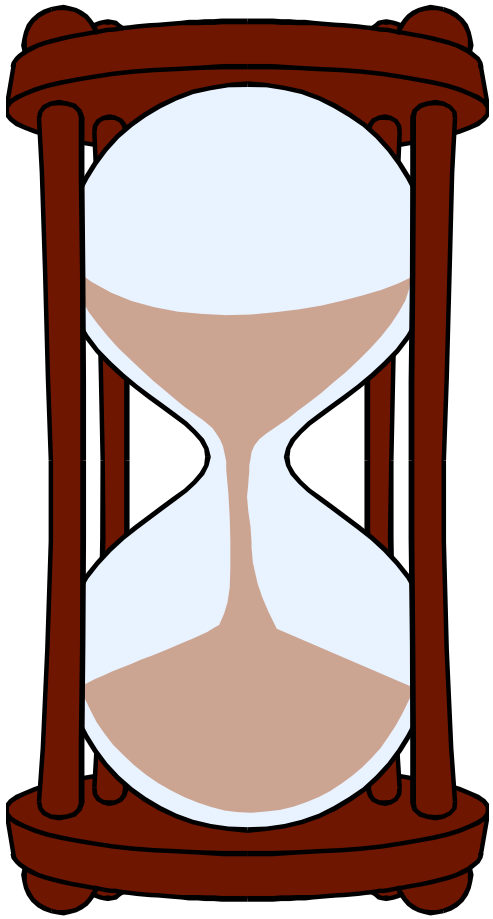

Source: Coal consumption projections based on EIA Reference Case from "Annual Energy Outlook 2002", and include all coal electric generation except cogenerators. Historical coal consumption from EIA "Annual Energy Review 2000" and includes only utility electric generation.

# Proposed Emissions Reductions

## *Electric Power Plants*

| | | | Clear Skies | | Jeffords |
|---|---|---|---|---|---|
| *Emission* | *Actual 1999* | *Baseline* | *2008/2010 Cap* | *2018 Cap* | *2007 Cap* |
| $SO_2$ | 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 |
| $CO_2$ | 2.19 B tons/yr | ? | None | None | 1.94 B tons/yr |

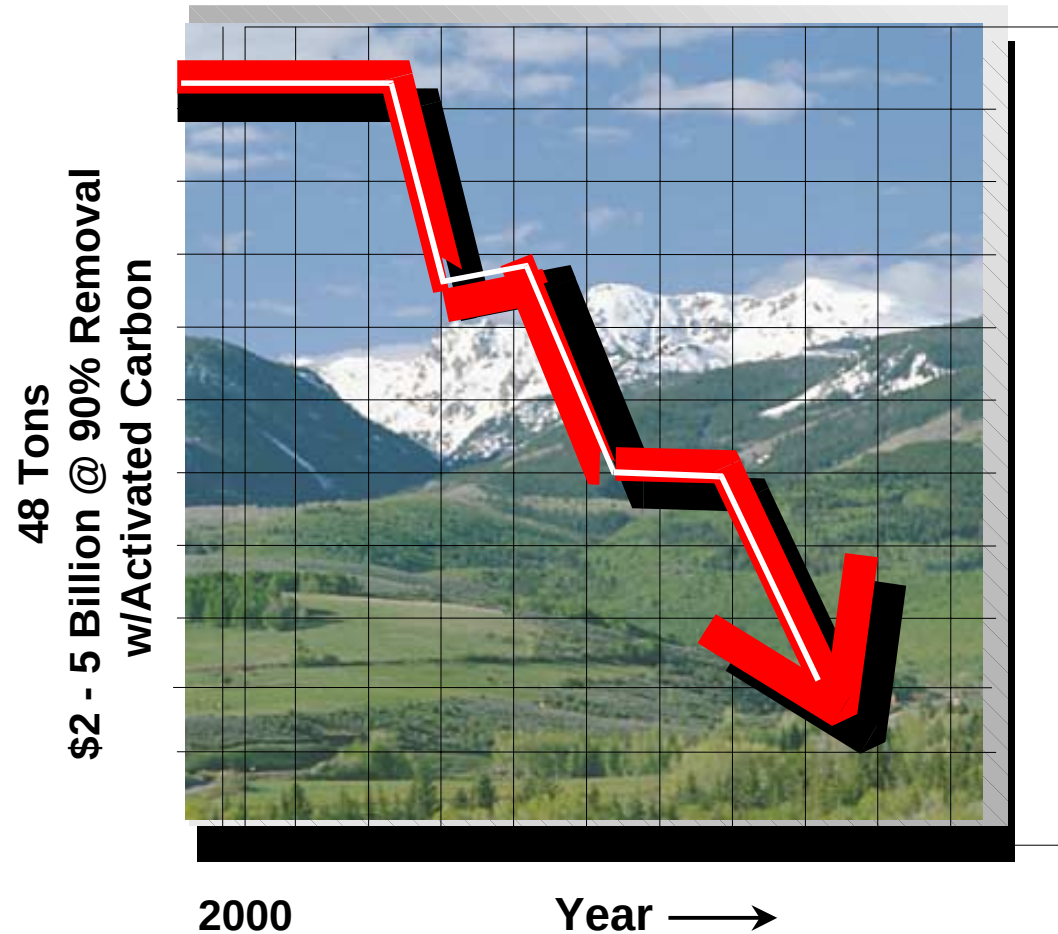
# EPA's Maximum Achievable Control Technology (MACT) Process



- 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

Sorbent Injection

Enhanced Scrubbing

48 Tons

Boiler

Particulate Control

FGD System

Stack

80 Tons

75 Tons

55 Tons

48 Tons

# Hg Field Test Schedule

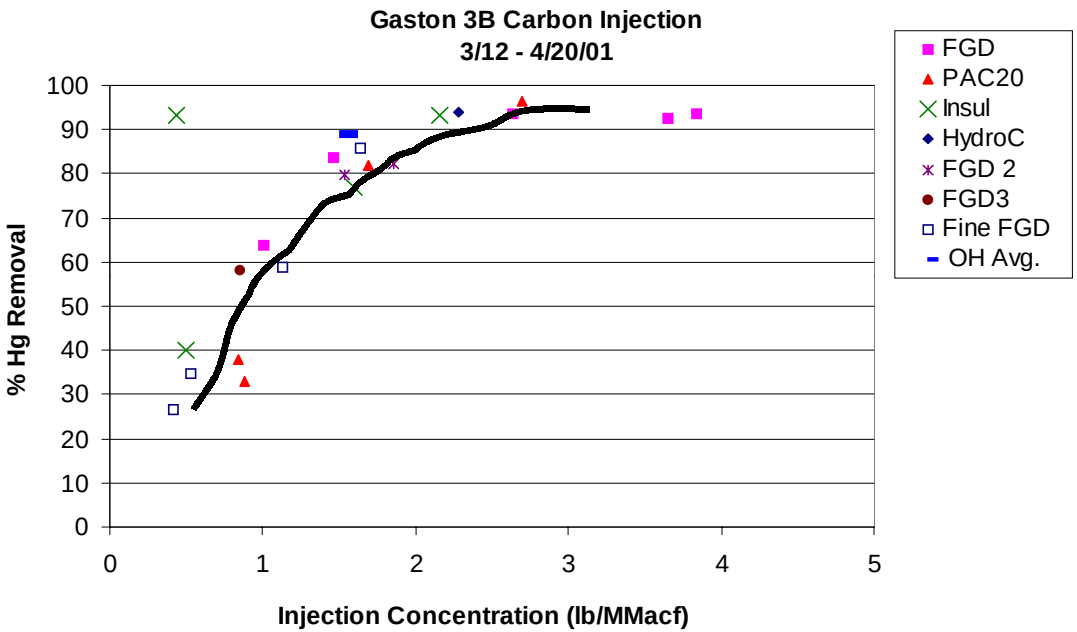
| *Technology/Utility-Plant* | *Testing Date* |
|---|---|
| ***ADA-ES – Sorbent Injection*** | |
| ***Alabama Power - Gaston*** | March-April, 2001 |
| ***WEPCO - Pleasant Prairie*** | September-November, 2001 |
| ***PG&E – Salem Harbor*** | June-July, 2002 |
| ***PG&E – Brayton Point*** | October-November,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

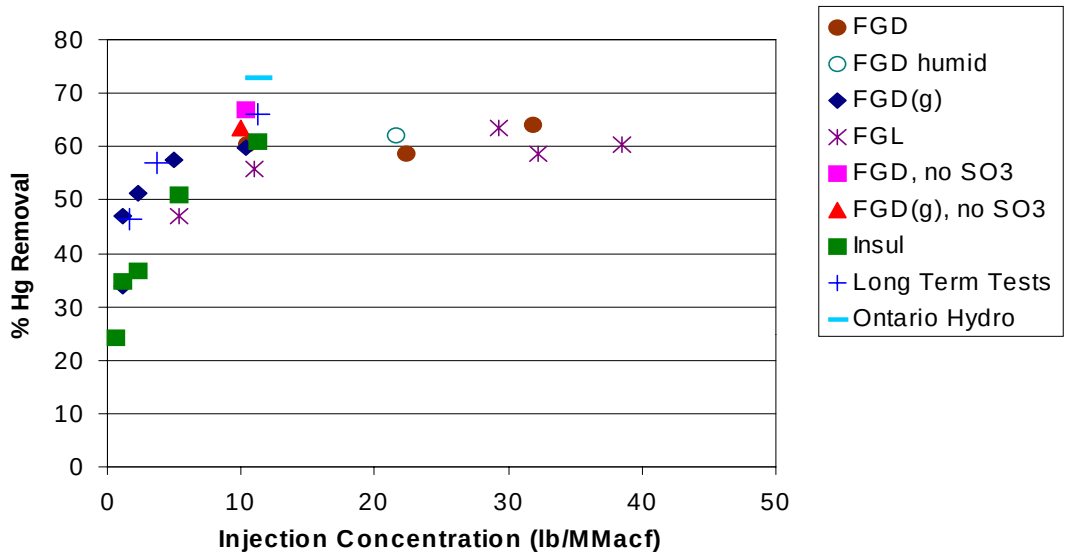



***78% Average Total Mercury Removal***

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

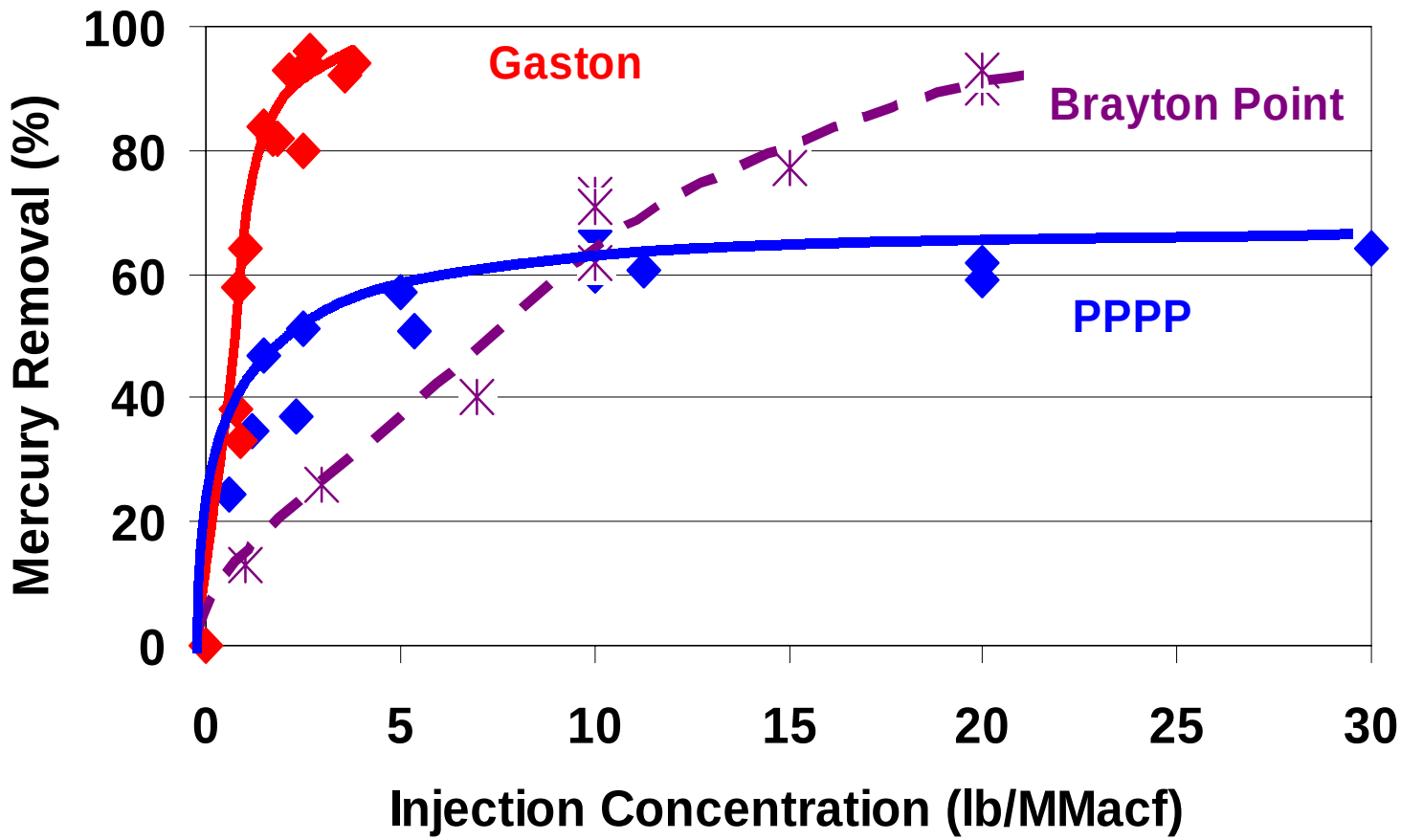
# Hg Field Testing
# WEPCo's Pleasant Prairie Station

- 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, $SO_2$, and acid gases
- **Southern Research Institute**
  - Calcium-based additives for controlling mercury
- **Powerspan Corp.**
  - Multi-pollutant control technology to remove Hg, $SO_2$, $NO_x$, particulates, and acid gases
- **Apogee Scientific**
  - Advanced mercury sorbents

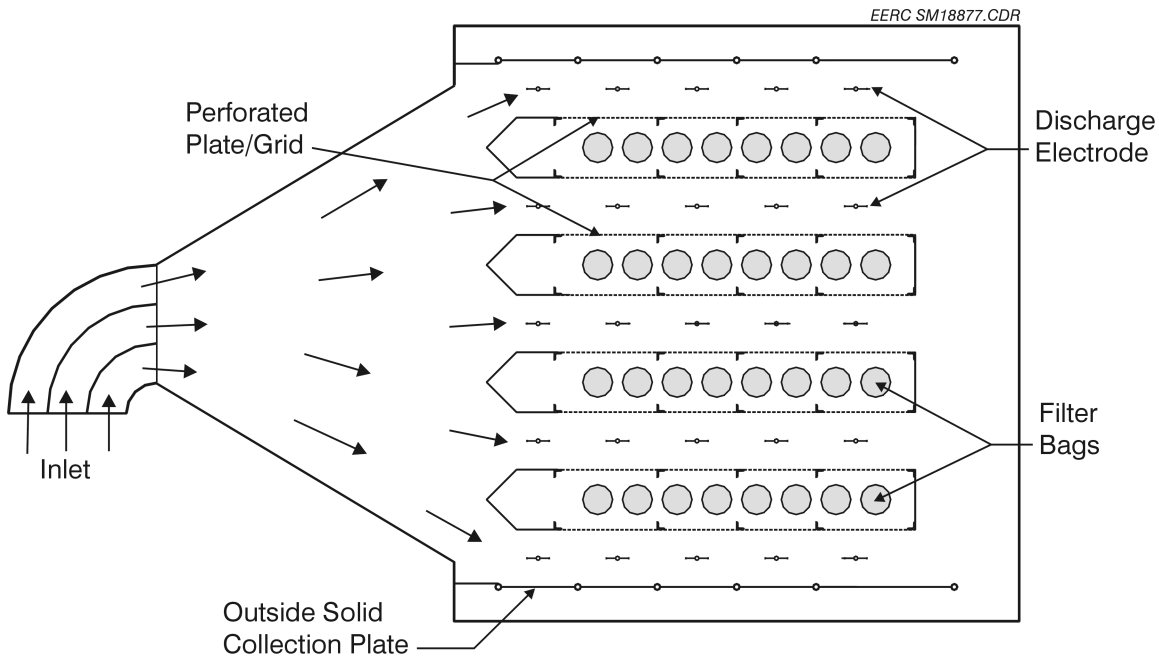
***Designed to Achieve ≥ 90% Hg Removal***

# 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

- **Initiate long-term (1 year) testing of ACI at Southern Company's Gaston Station**

- **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.)

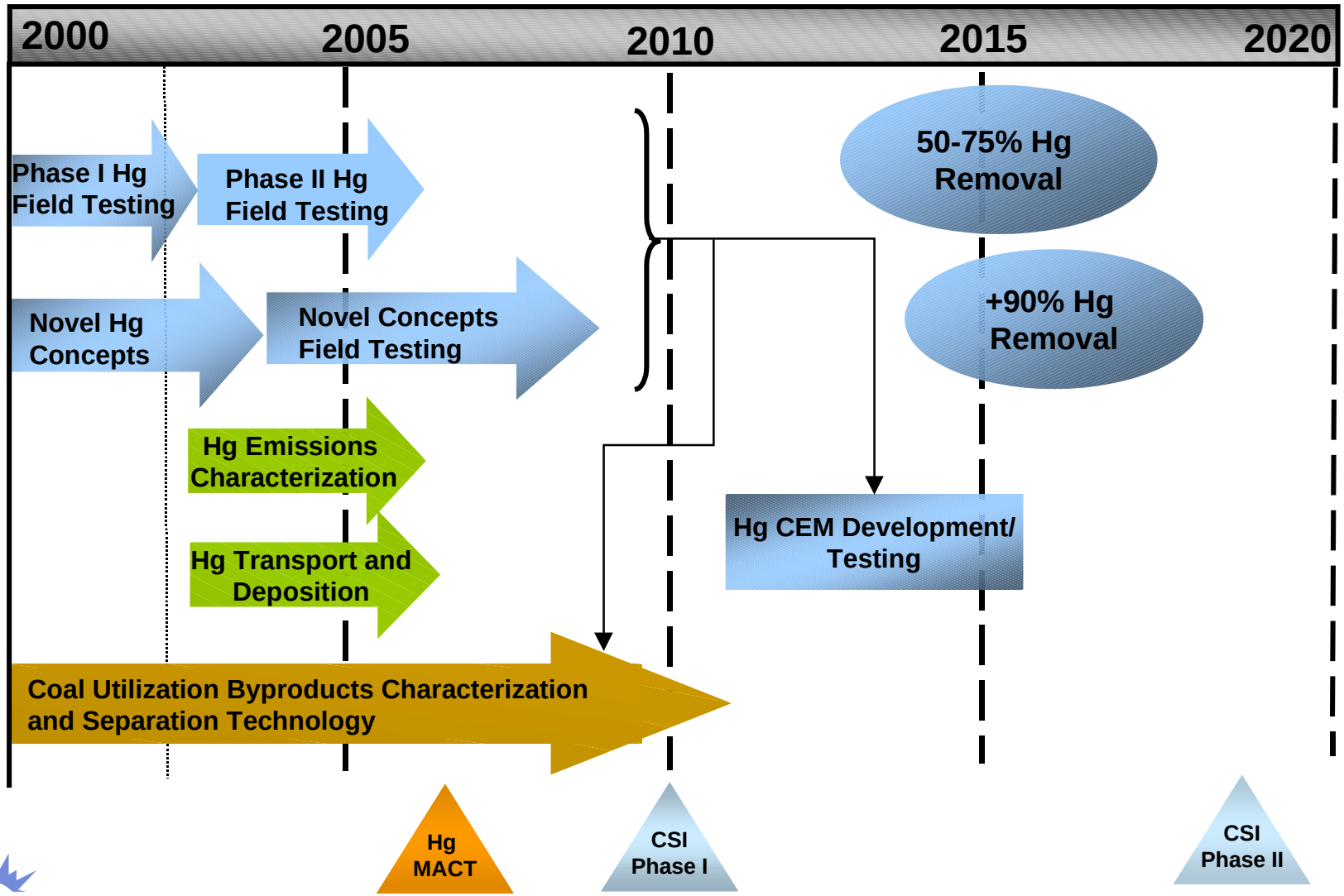

*Mercury Wet Deposition Monitor near Holbrook, Greene County, PA*

- **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

# Hg Control Technology Roadmap



# 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 on NETL's Hg R&D Program...

- Visit IEP website at:


***www.netl.doe.gov/coalpower/environment***