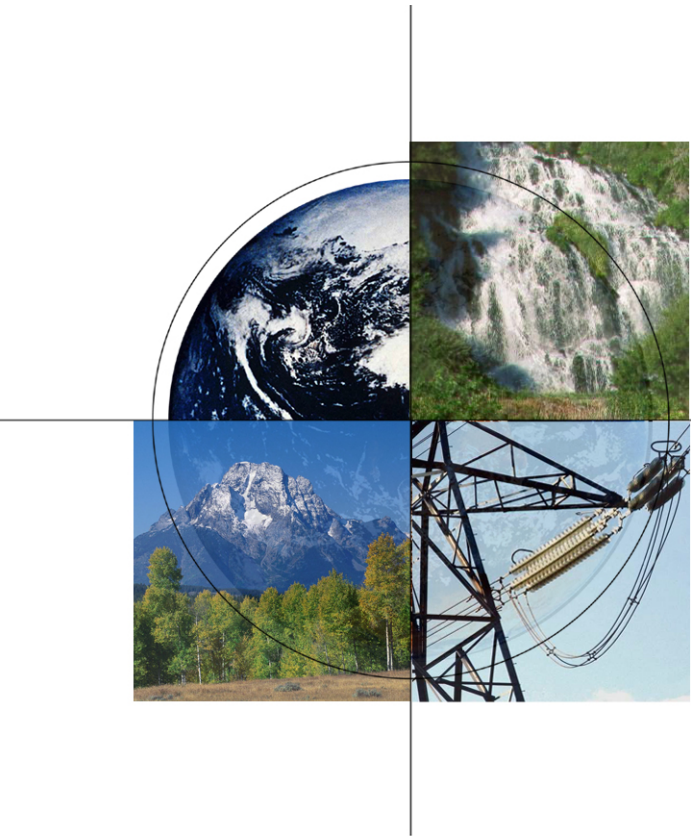
Mercury Emissions Control Technology– DOE's R&D Program



American Chemical Society/American Institute of Chemical Engineers Monthly Meeting

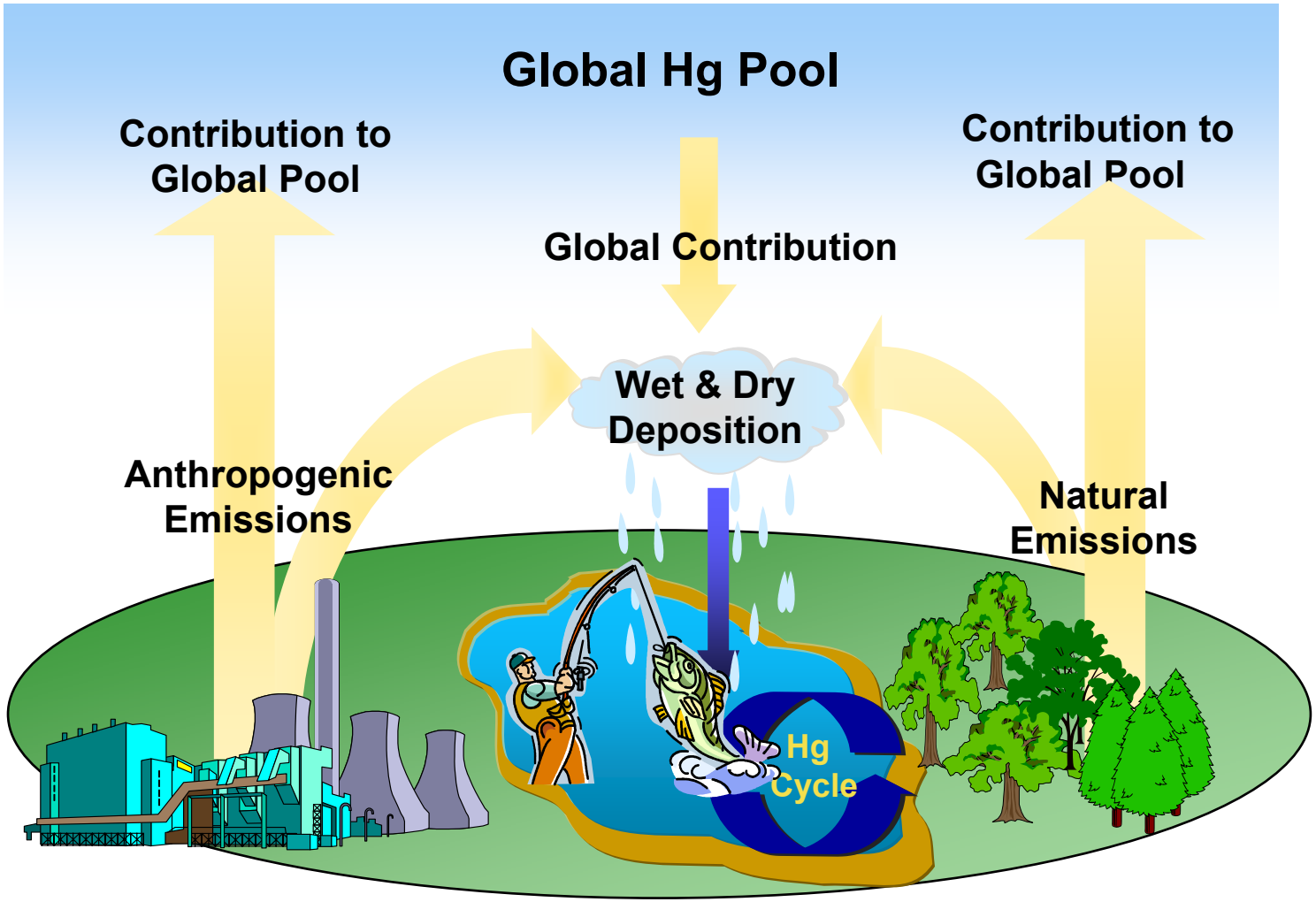
November 4, 2004
Pittsburgh, PA

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

Outline

- Background
- DOE's RD&D program
- Future plans

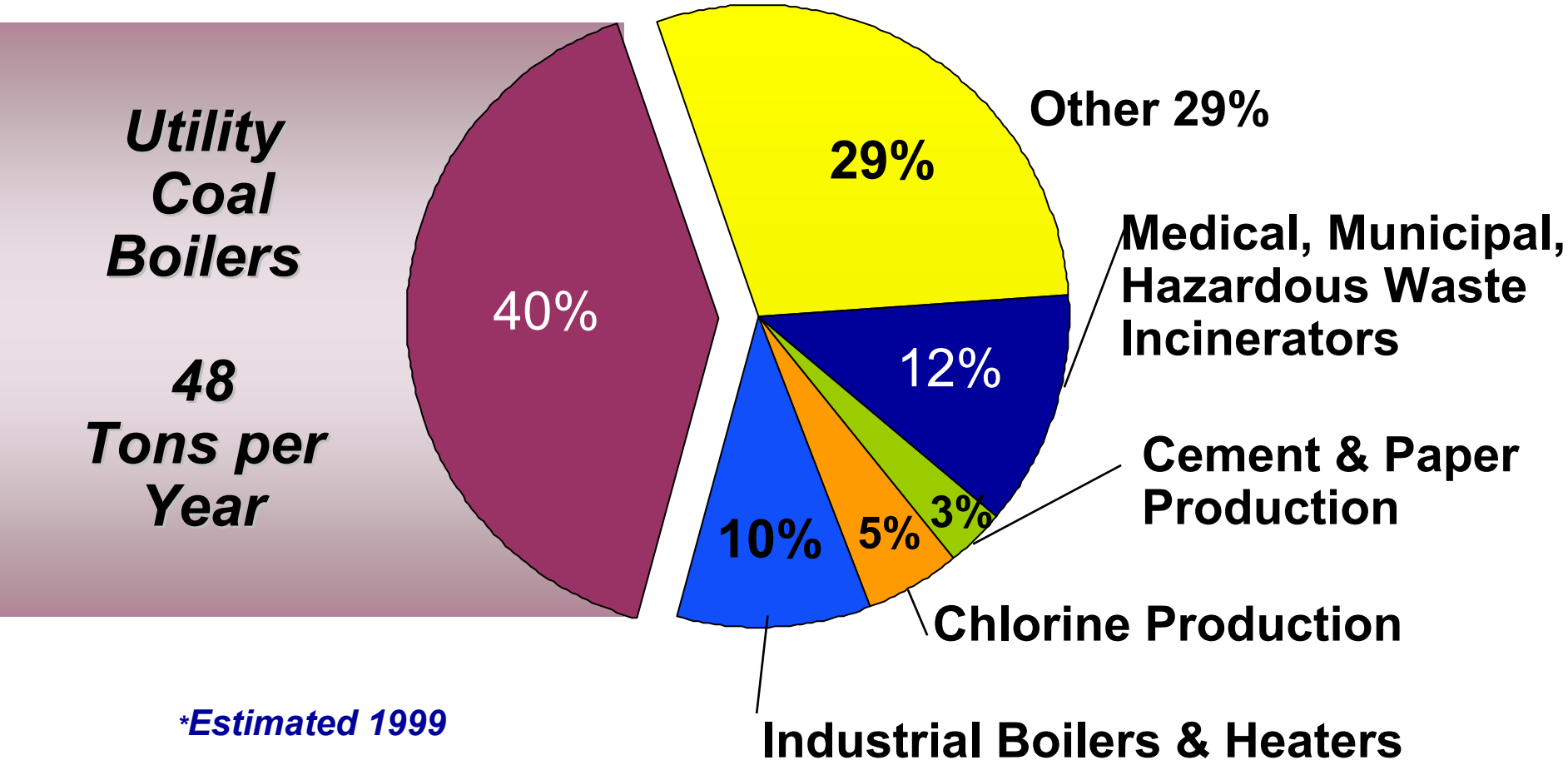
Global Mercury Pool



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

U.S. Anthropogenic Mercury Emissions*

120 Tons per Year

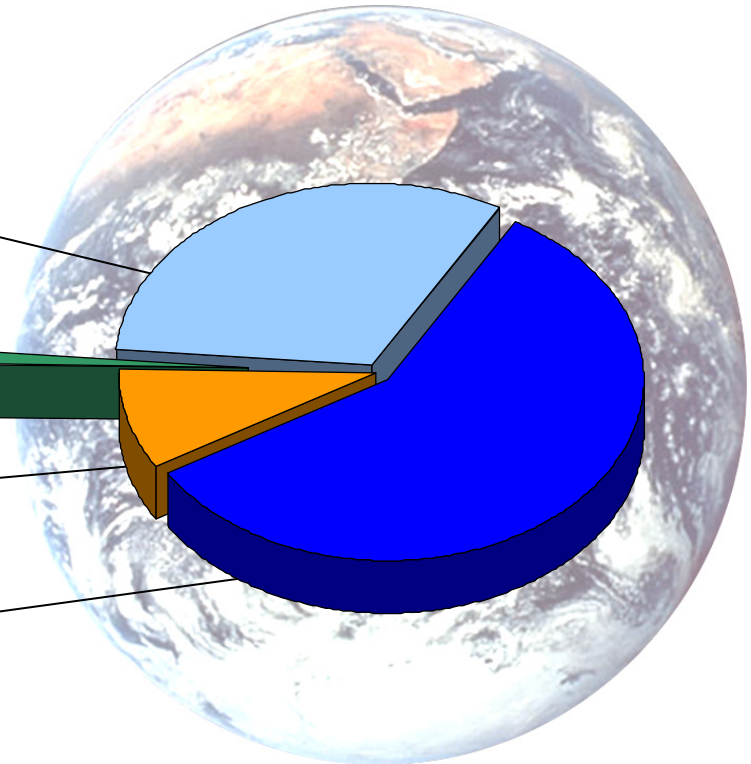


*Estimated 1999

Source: Personal communication with U.S. EPA 7/16/03 1999 NEI Version 3.0

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

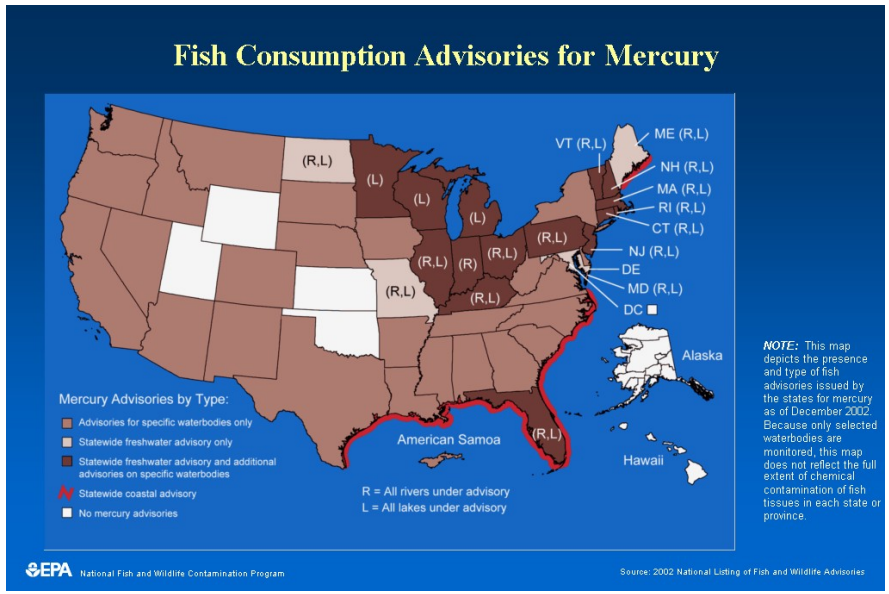
FACT: It is estimated that U.S. coal-fired power plants emit approximately 1% of annual global mercury emissions

Source: UNEP Global Mercury Assessment, December 2002

Will Reductions in Power Plant Mercury Emissions Solve The Problem?

According to the U.S. EPA, "40% of mercury deposition in the continental United States is attributable to foreign sources."

Additionally, "even if all feasible controls for Hg are implemented in the U.S., external sources will prevent attainment of water quality standards."



Source: *Terry Keating, U.S. EPA, Clean Air Report, 6/19/2003*

Mercury Regulation or Legislation?

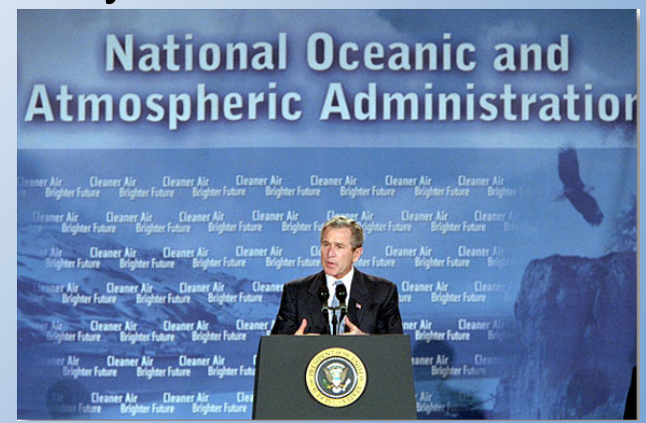
Regulation:

- EPA proposal issued 12/15/03
- Several alternatives for control offered for comment
- **Maximum Achievable Control Technology (MACT)**
  - Plant-by-plant – no trading
  - Approx. 29% reduction by 2007/08
- **Cap & Trade**
  - FGD/SCR co-benefit (29% reduction) by 2010
  - 15 ton cap (69% reduction) by 2018

?

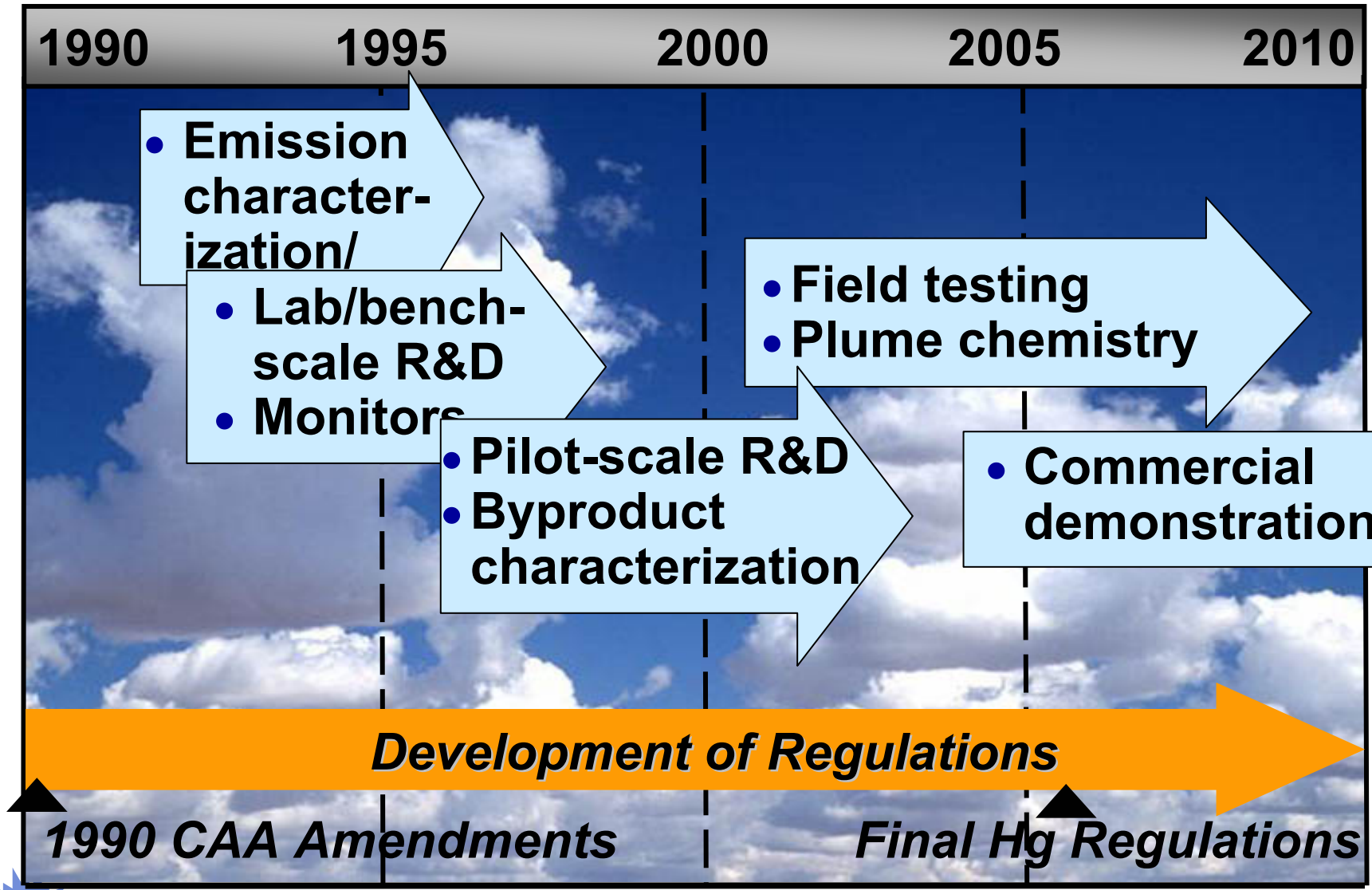
Legislation:

- **Clear Skies Act of 2003**
  - Cap & trade
  - 34 ton cap (29% reduction) by 2010
  - 15 ton cap (69% reduction) by 2018

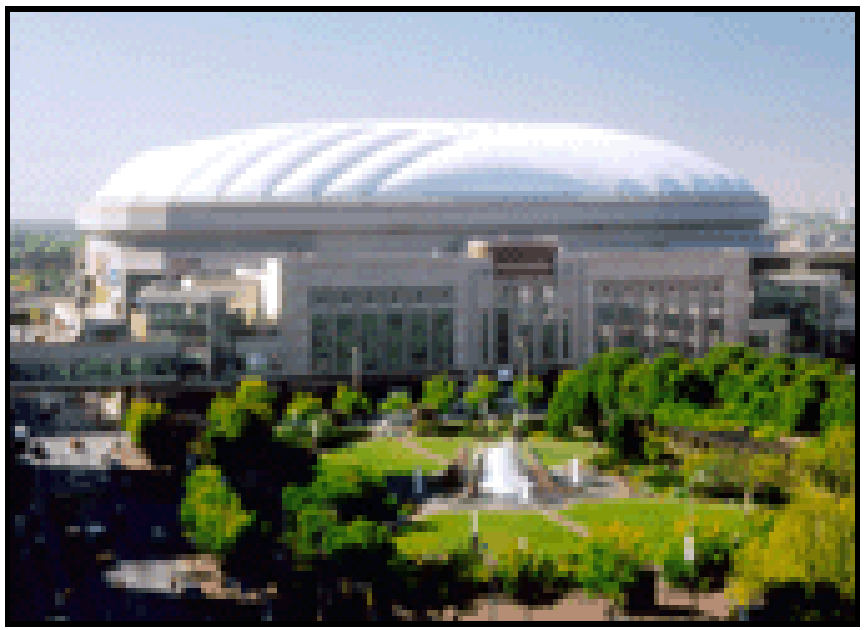


President Bush Announcing Clear Skies Initiative February 14, 2002

History of Mercury R&D



Capturing Mercury Challenging!

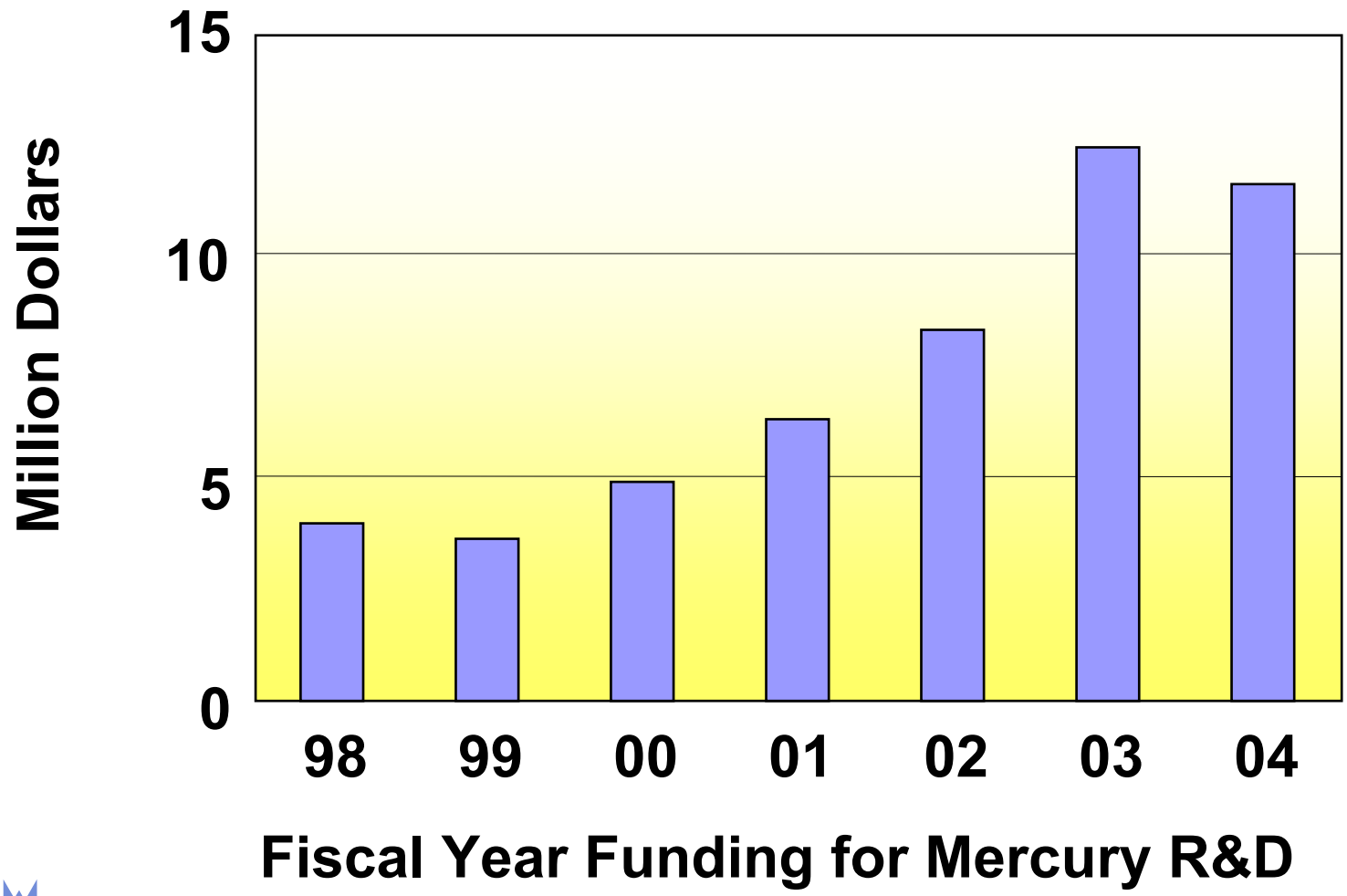


RCA Dome

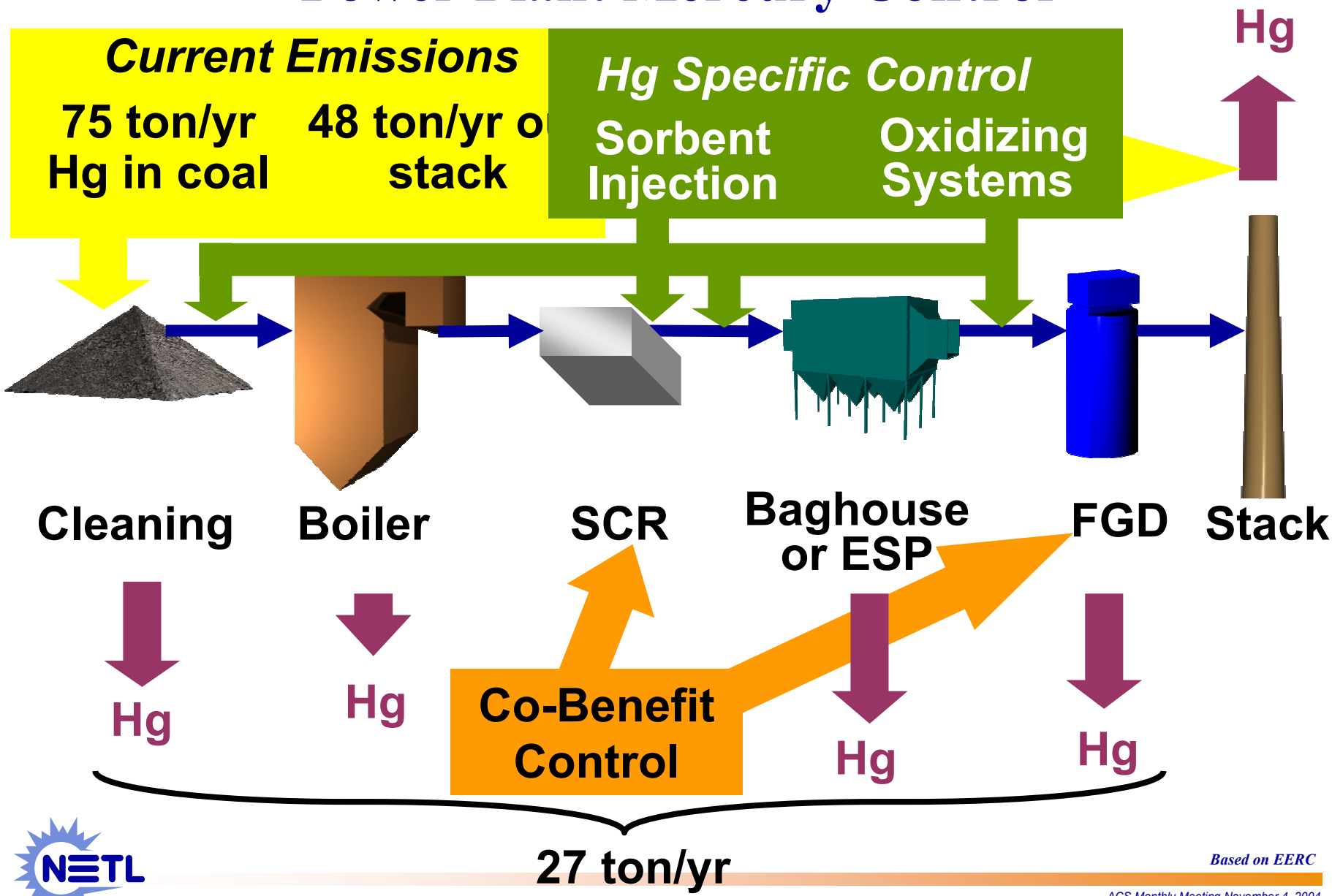
A Hypothetical Example

- **RCA Dome filled with 30 billion ping-pong balls**
- **30 black mercury balls**
- **Find and remove 27 black balls for 90% Hg capture**

DOE Spent Over $50 Million on Mercury R&D Over Past Seven Years



Power Plant Mercury Control



DOE Mercury Control RD&D Portfolio

Boiler
- Combustion modification
- Chemistry modification

Polishing Technology
- MerCAP™

Plume Chemistry
- Transport/ speciation

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

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

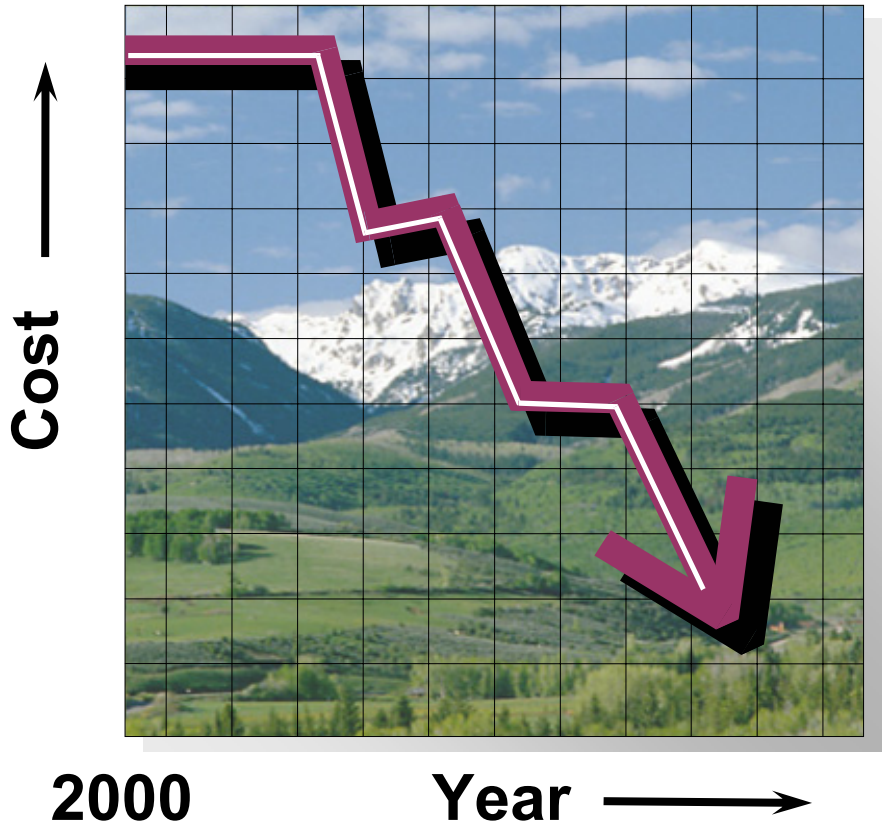
Coal Combustion Byproduct Characterization

NETL

Mercury Field Testing Program

Objectives

- **Have technologies ready for commercial demonstration**
  - by 2005 for bituminous coal
  - by 2007 for low-rank coal
- **Reduce emissions 50-70%**
- **Reduce cost by 25-50% compared to baseline cost estimates**



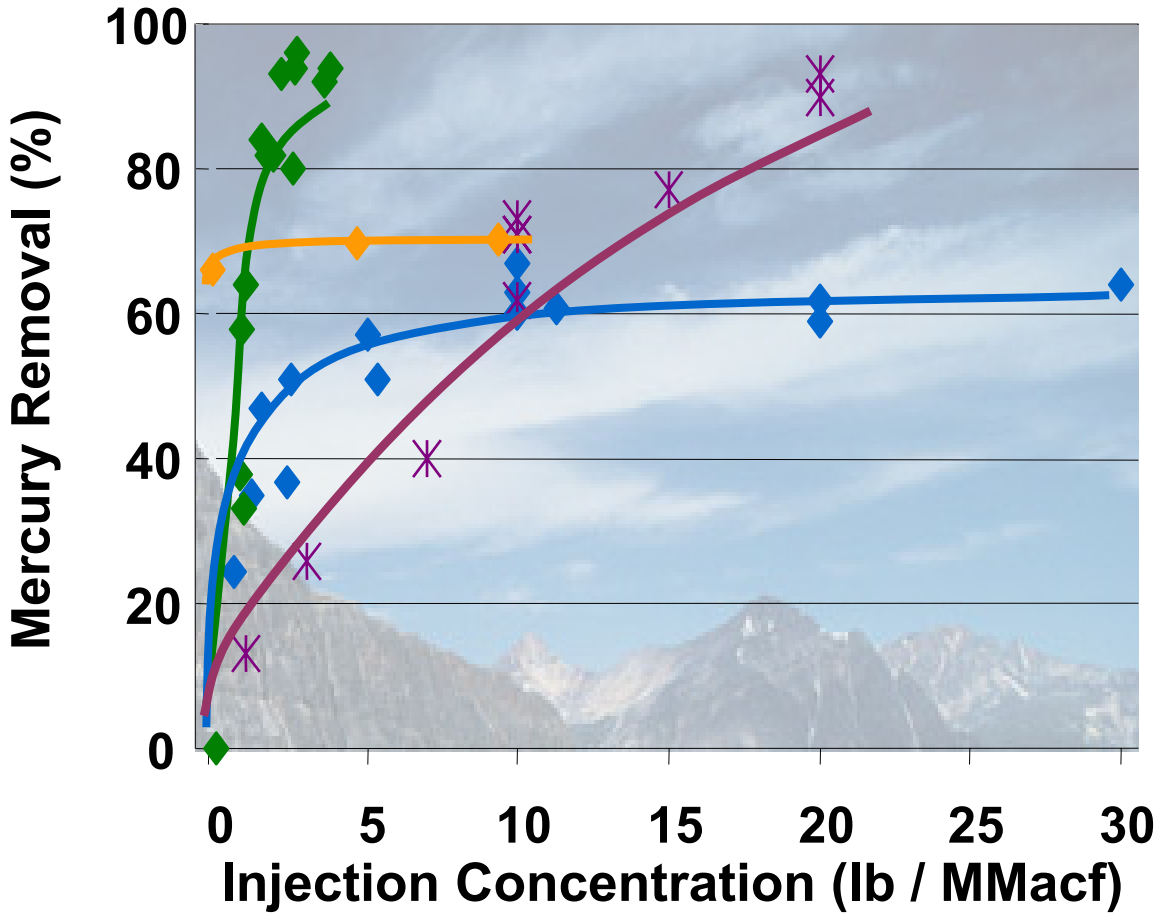
Baseline Costs: $50,000 - $70,000 / lb Hg Removed

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

ADA-ES Phase I Field Test Results

Activated Carbon Injection



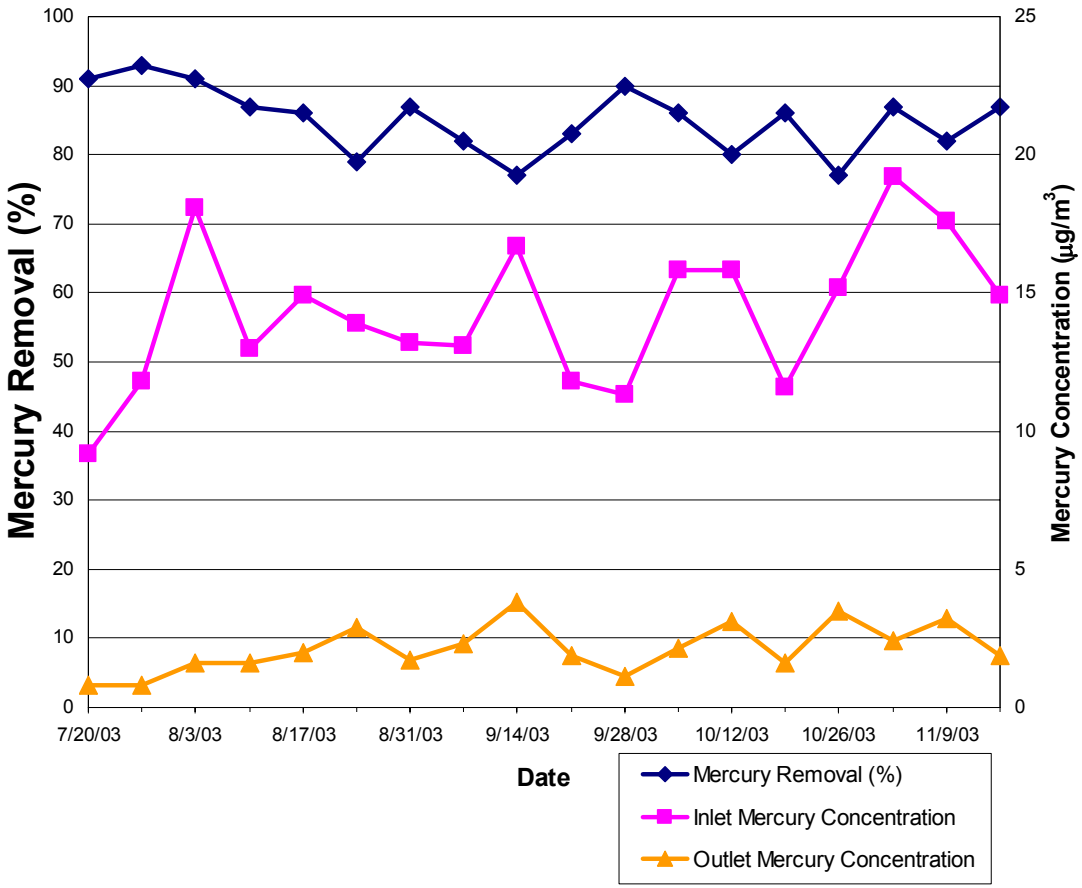
Gaston:
Bituminous coal,
ESP + fabric filter

Salem Harbor:
Bituminous coal, ESP
(gas temp. at 280-290 °F)

Pleasant Prairie:
Subbituminous coal, ESP

Brayton Point:
Bituminous coal, ESP

Long-term Testing at Gaston Station



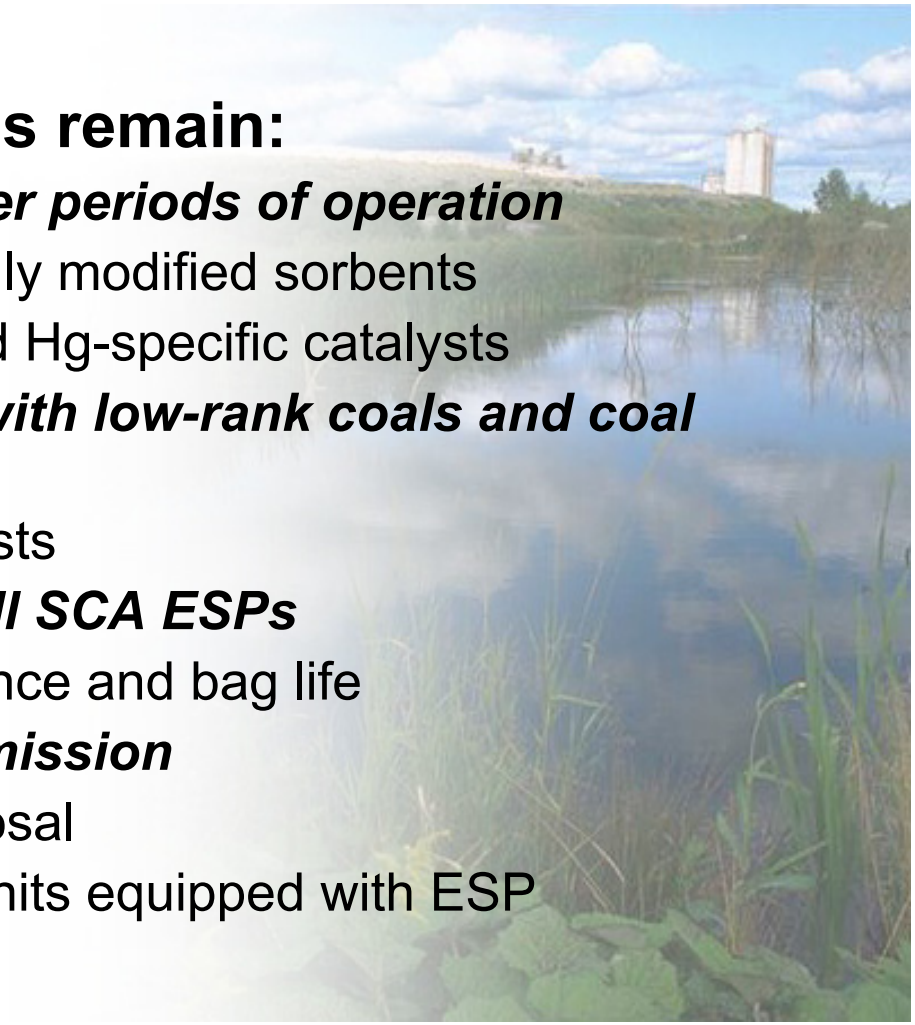
- **Average Hg Removal**
  - 86 %
- **Average Inlet Concentration**
  - 14 µg/m^3
- **Average Outlet Concentration**
  - 2 µg/m^3

Average Weekly Data from S-CEM Measurements

Observations From Phase I Field Tests

- **Moderate to high mercury capture possible with ACI:**
  - Performance depends on:
    - Particulate system – FF or ESP
    - Coal rank
    - Flue gas temperature
- **Scrubber enhancers show modest improvement in capture effectiveness**

Observations From Phase I Field Tests



- **However, uncertainties remain:**
  - ***Performance over longer periods of operation***
  - Effectiveness of chemically modified sorbents
  - Effectiveness of SCR and Hg-specific catalysts
  - ***Capture effectiveness with low-rank coals and coal blends***
  - Sorbent feed rate and costs
  - ***Effectiveness with small SCA ESPs***
  - Impact on ESP performance and bag life
  - ***FGD Hg reduction/re-emission***
  - By-product use and disposal
  - Need for fabric filter for units equipped with ESP

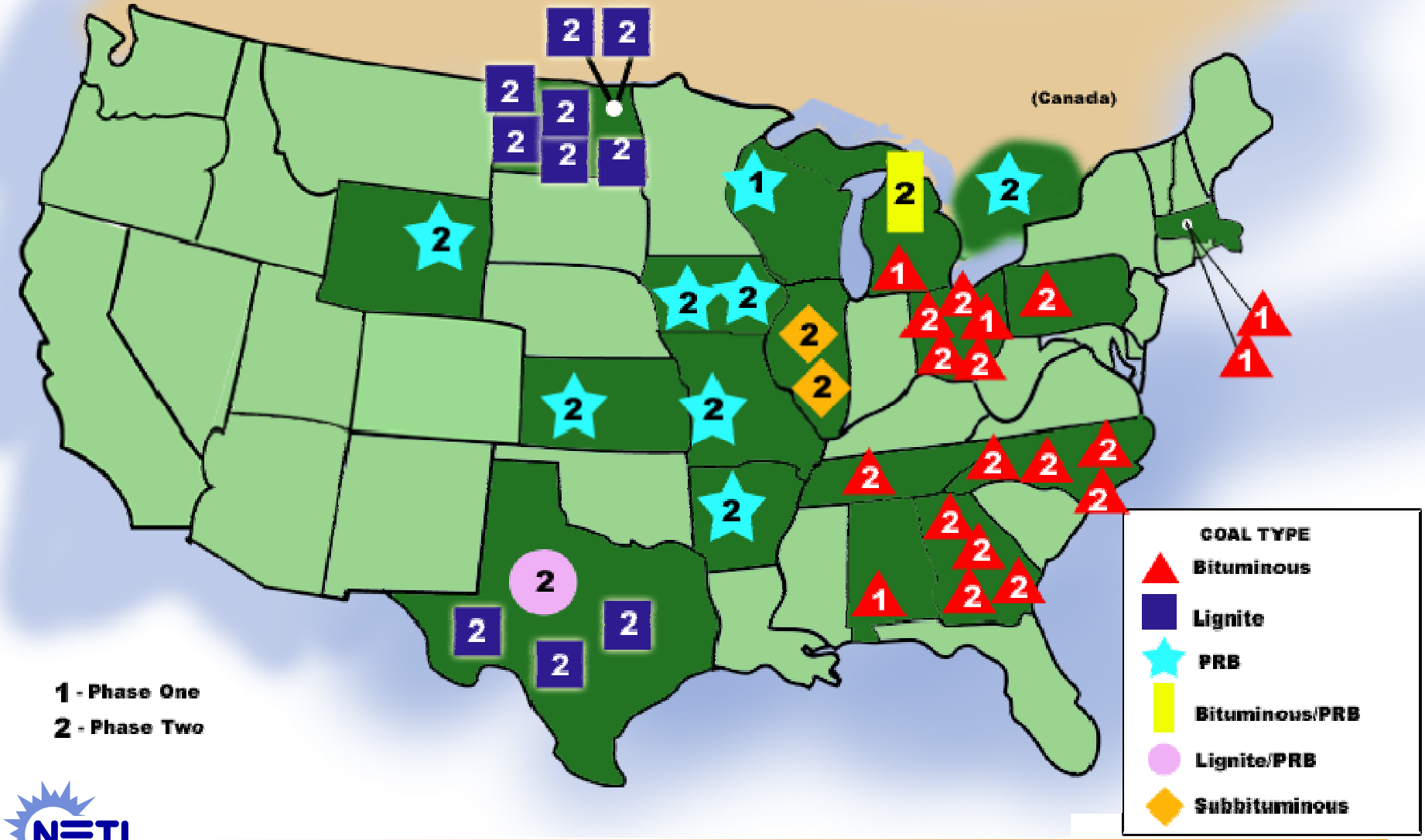
Phase II Mercury Control Field Test Projects

- 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

Phase II Hg Field Testing Program

Hg Control Approach	Host Sites	Coal Types	Downstream Control Equipment
Activated carbon injection (ACI)	13	PRB, Bit., PRB/Bit. blend	FF, ESP, ESP w/ NH_3/SO_3 injection
Amended silicates	1	Bituminous	ESP
Oxidation catalyst	2	TX lignite, bituminous	ESP, ESP/wet FGD
Chemical inject. w/ ACI, chem. mod. ACI	4	ND lignite	ESP, FF/SDA
Chlorine injection	2	ND lignite, TX lignite	ESP/wet FGD
FGD enhancement	3	Lignite, HS & LS bituminous	Wet FGD
Combustion modification	1	Bituminous	ESP
Fixed structure gold sorbent	2	ND lignite, bituminous	FF/SDA, ESP/wet FGD
Halogenated ACI	5	Bit., bit/PRB blend	HSESP, ESP

DOE/NETL Phase I and II Mercury Field Sites

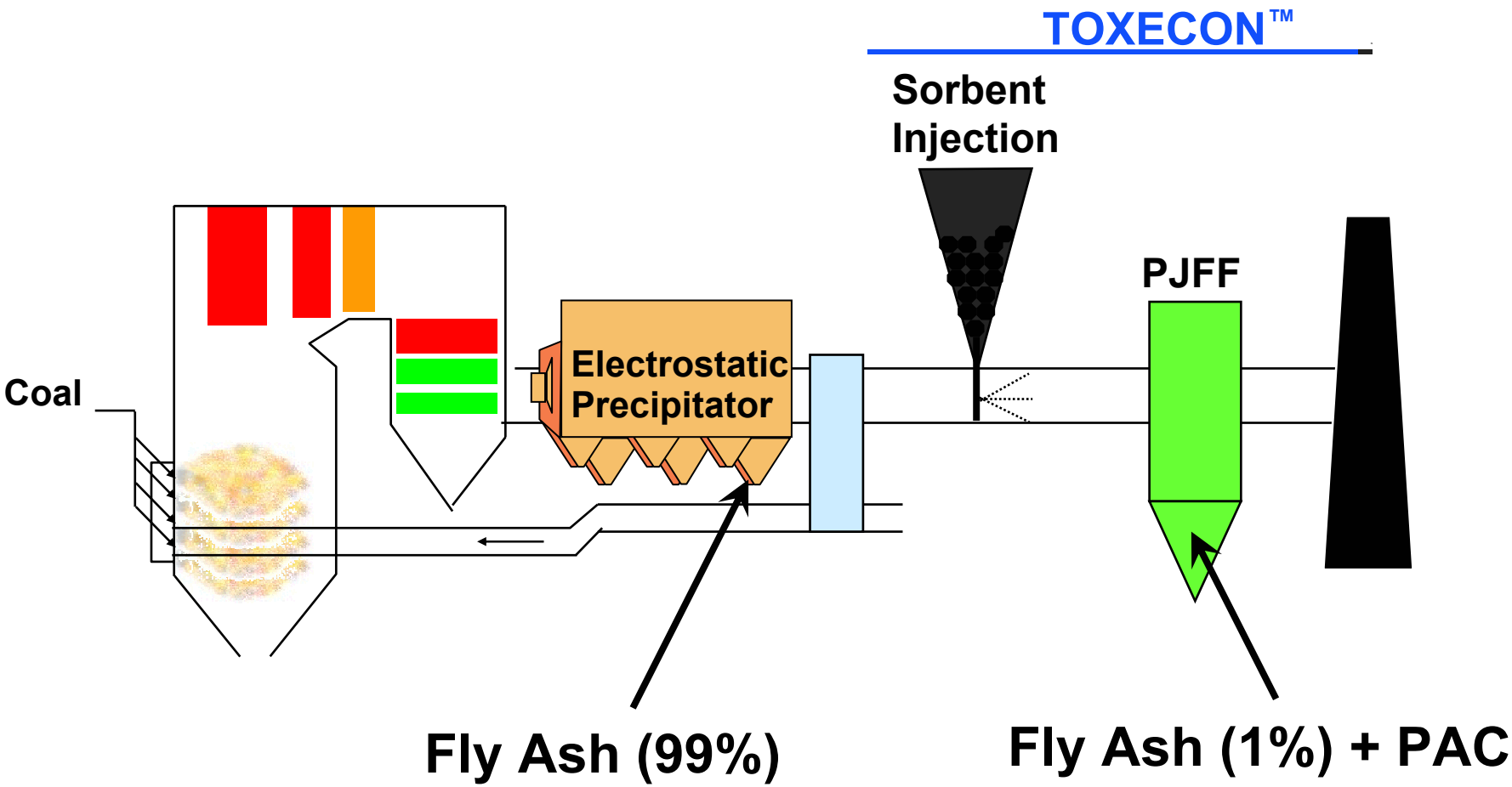


Full-Scale Demonstration of Toxecon™ Retrofit for Mercury and Multi-Pollutant Control

- **Demonstrate:**
  - Multi-pollutant control with PRB coal
    - 90% Hg reduction
    - 70% SO_2 reduction
    - 30% NOx reduction
  - Hg recovery from sorbent
  - Hg CEM performance

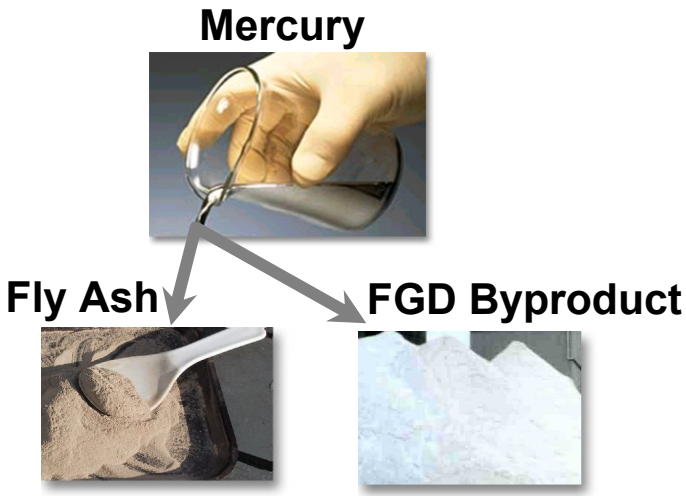
We Energies Presque Isle Power Plant

TOXECON™ Configuration



Challenges to Increased CUB Utilization

- **Future air pollution regulations, e.g., Hg MACT/Cap-and-Trade**
  - Increase volume of coal utilization by-products
  - Change characteristics (i.e., quality) of by-products
- **Future solid waste regulations under RCRA?**
  - Limit use applications
  - Regulate coal utilization by-products as hazardous
- **Public perception**



- **NETL sponsoring research to assess fate of Hg and other trace elements in byproducts from Hg field testing projects**

Hazardous Waste Designation of All By-products Could Cost $11 Billion / Year

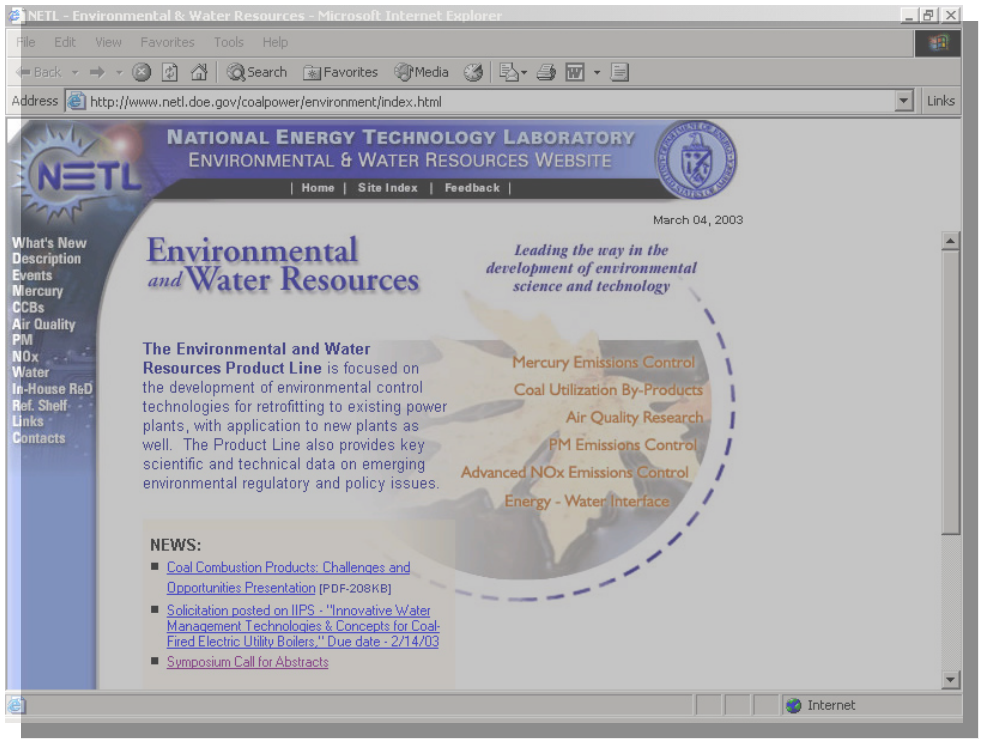
Summary

- 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
- DOE currently field testing mercury control technologies on commercial coal-fired boilers as part of Innovations for Existing Plants Program
- First-of-a-kind full-scale commercial demonstration of ACI being carried out under DOE's Clean Coal Demonstration Program
- Further RD&D needed to fully address technical and performance uncertainties

Future Plans

- Continue Phase II field testing of technology capable of achieving 50-70% Hg removal through FY06
- Carry out field testing of technologies capable of achieving +90% Hg capture starting in FY06-07
- Commercially demonstrate promising Hg technologies selected under DOE's Clean Coal Power Initiative
- Continue characterization of byproducts from Hg field testing projects
- Assess economics of Hg control technologies based on results of field testing
- Evaluate promising pre-combustion Hg removal technology

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