DOE-NETL's Mercury R&D Program

EPRI Mercury Workshop

November 6-7, 2002
St. Louis, MO

Thomas J. Feeley, IIII
National Energy Technology Laboratory

Potential Mercury Regulations

MACT Standards

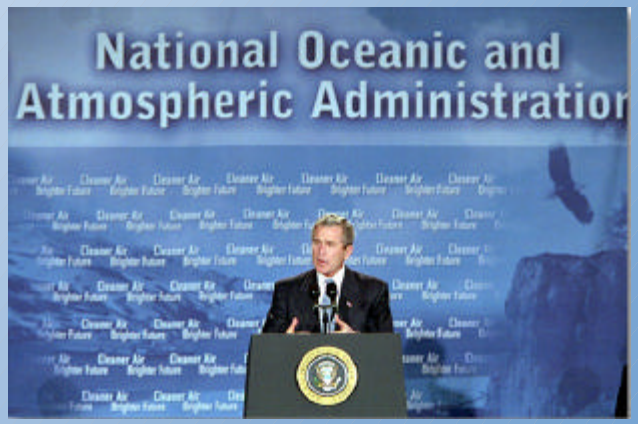
- Likely high levels of Hg reduction
- Compliance: 2007

Clean Power Act of 2001

- 4-contaminant control
- 90% Hg reduction by 2007

Clear Skies Act of 2002

- 3-contaminant control
- 46% Hg reduction by 2010
- 70% Hg reduction by 2018
- Hg emission trading

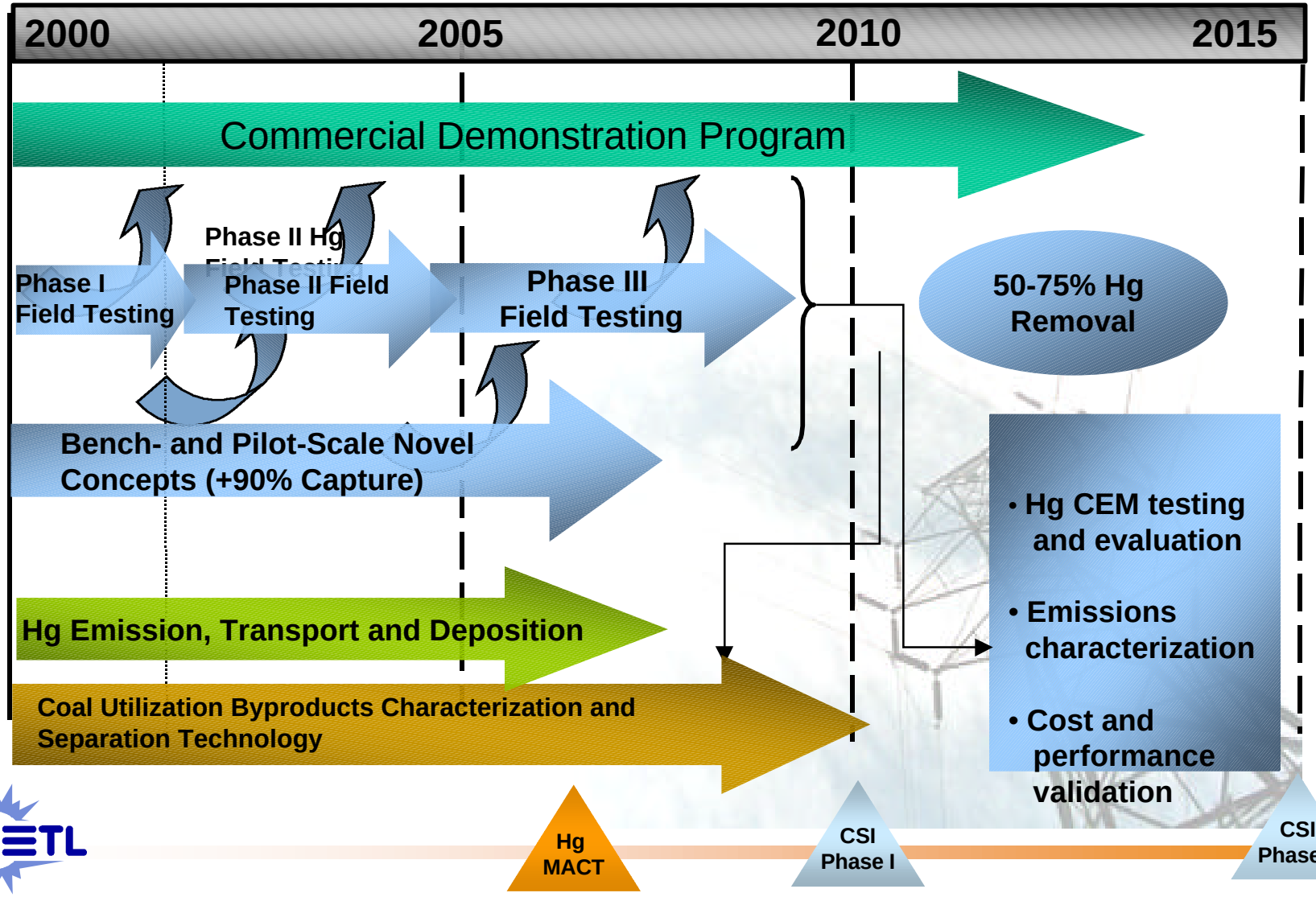


President Bush Announcing Clear Skies Initiative February 14, 2002

DOE-NETL's Mercury R&D Program

- **Focus on:**
  - Control technology development
  - Coal byproduct characterization
  - Emissions characterization and methods development
  - Deposition measurement
  - Plume chemistry and transport
  - Supporting systems analysis
- **Strong partnership with industry and EPRI**

Hg Control Technology Roadmap



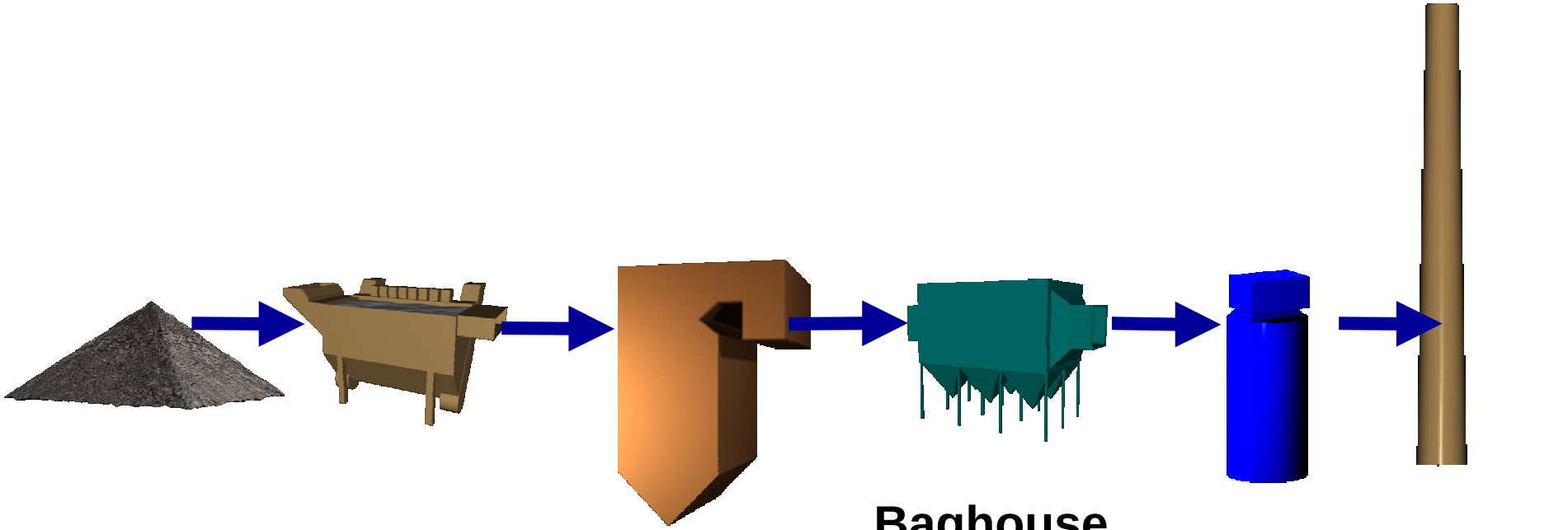
Estimated Funding for Mercury R&D

FY01	FY02	FY03[1.]	FY04[2.]
$2,500,000	$5,700,000	$9,000,000	$20,000,000

1. Does not include Senate ($1,000,000) or House ($4,000,000) add

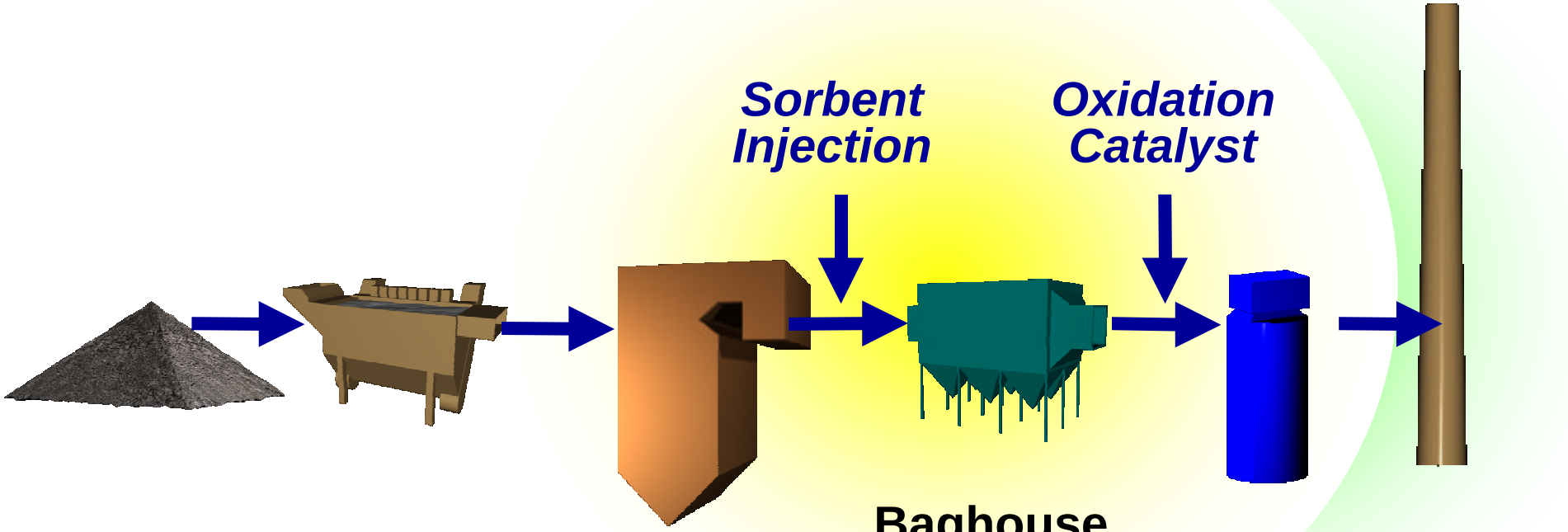
2. Based on FY04 President's Budget

Mercury in a Power Plant



Based on EERC

Mercury Control Options



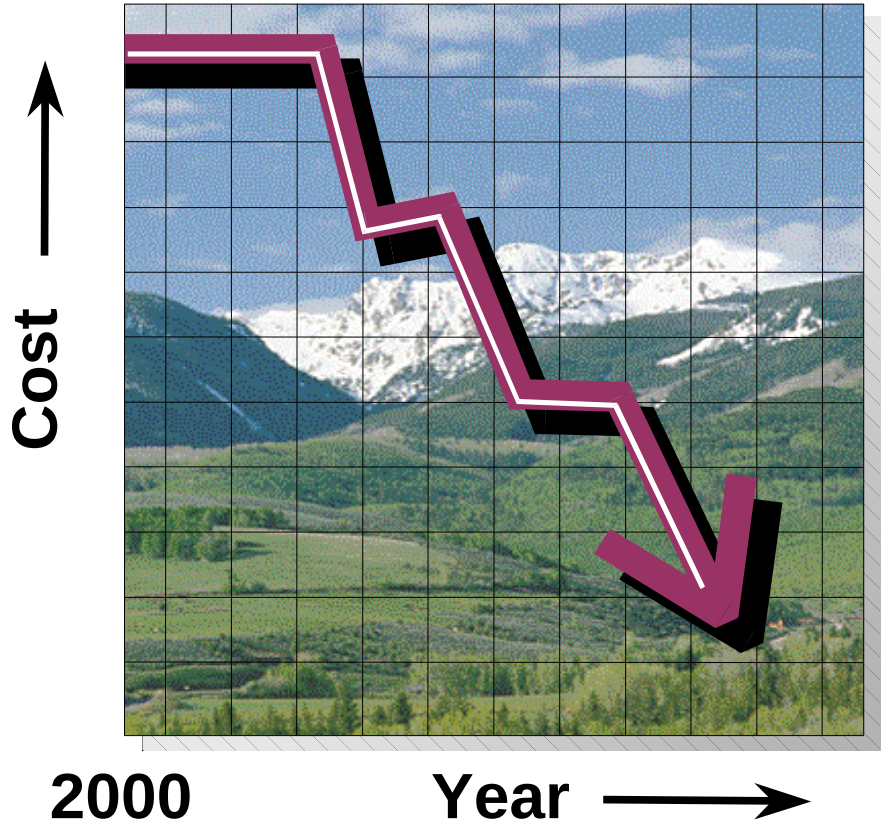
Based on EERC

R&D Goals

DOE Mercury Control Program

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 / lb Hg Removed

Six Mercury Control Field Tests

Technology / Utility Plant	Start Date
ADA-ES – Sorbent Injection	
Alabama Power – Gaston	March 2001
We Energies – Pleasant Prairie	September 2001
PG&E – Brayton Point	June 2002
PG&E – Salem Harbor	September 2002
McDermott-B&W – Enhanced Scrubbing	
Michigan South Central Power – Endicott	May 2001
Cinergy – Zimmer	October 2001

ADA-ES Field Test Sites

Alabama Power – Gaston

- 135 MW
- Low-sulfur bituminous coal
- ESP
- COHPAC fabric filter

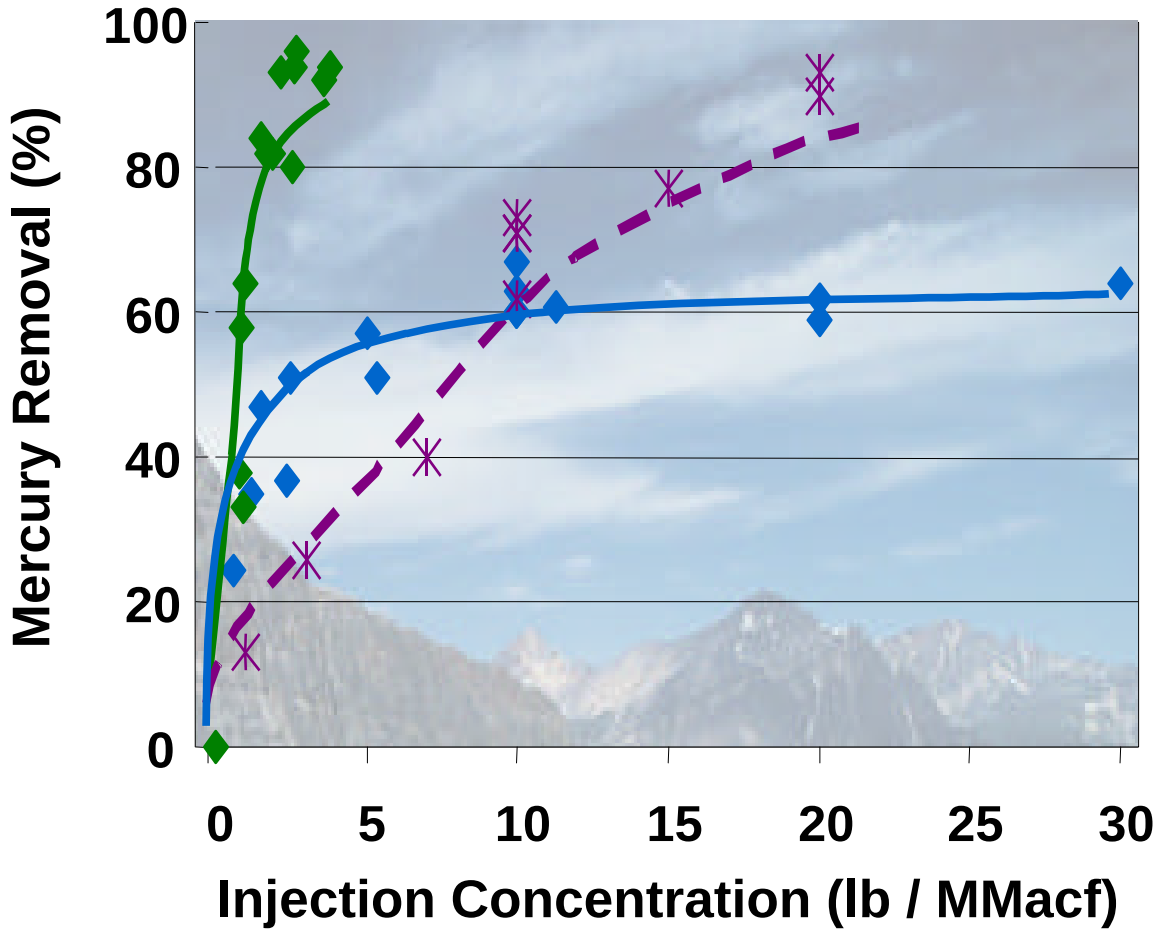
We Energies – Pleasant Prairie

- 150 MW
- Subbituminous coal
- ESP

PG&E – Brayton Point

- 122 MW
- Low-sulfur bituminous coal
- Low-NO_X burners
- Two ESPs in series

Mercury Removal Trends
Activated Carbon Injection



Gaston: **Bituminous coal, ESP + fabric filter**

Brayton Point: **Bituminous coal, ESP**

Pleasant Prairie: **Subbituminous coal, ESP**

Long-Term Sorbent Injection Testing
ADA-ES

- **Initiate long-term (~9 months) testing of sorbent injection technology at Alabama Power's E. C. Gaston Power Station**
- **Evaluate performance of TOXECON™ process -- pressure drop, bag strength/integrity, fly ash characteristics**
- **TVA, FirstEnergy, Allegheny Energy, Arch Coal, EPRI, Hamon Research-Cottrell, Ontario Power**

Advanced Mercury Control Concepts

- **Apogee Scientific**
  - Advanced Hg sorbents
- **CONSOL**
  - Multi-pollutant control for Hg, SO_2, acid gases
- **EERC**
  - Hybrid particulate control system
- **Powerspan**
  - Multi-pollutant control for Hg, SO_2, NO_x, particulates, acid gases
- **Southern Research Institute**
  - Calcium-based additives to control Hg
- **URS Group**
  - Catalyst to convert elemental to oxidized Hg

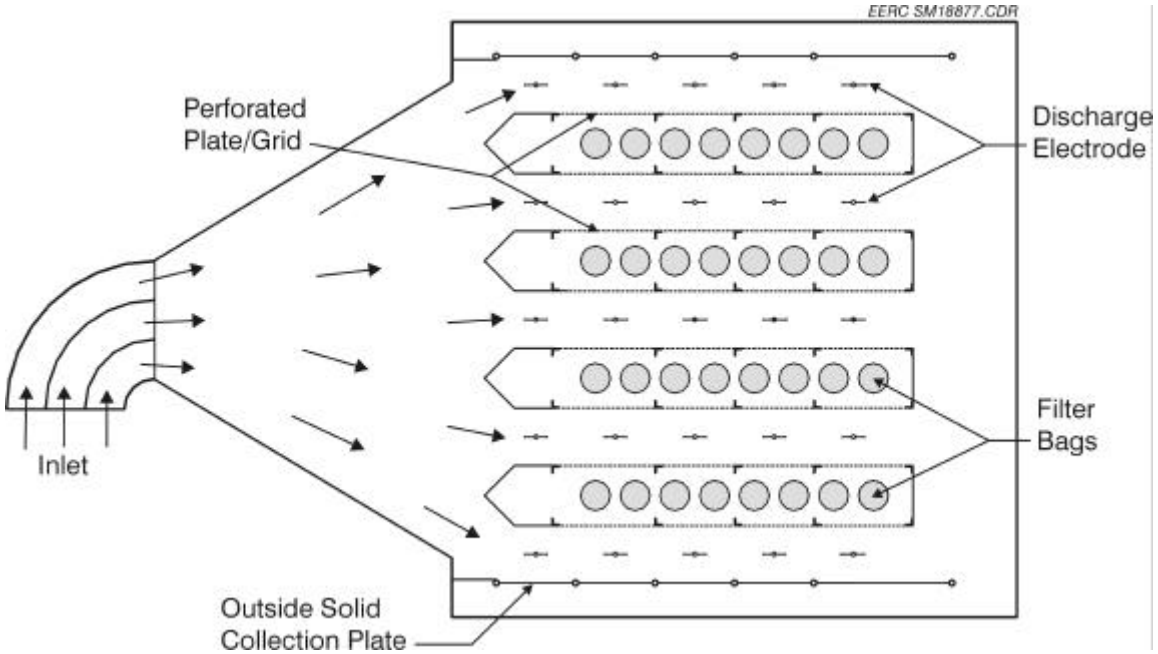
Designed to Achieve ≥ 90% Hg Removal

UNDEERC
Advanced Hybrid Particulate Collector

- **Evaluate sorbent injection**
  - 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

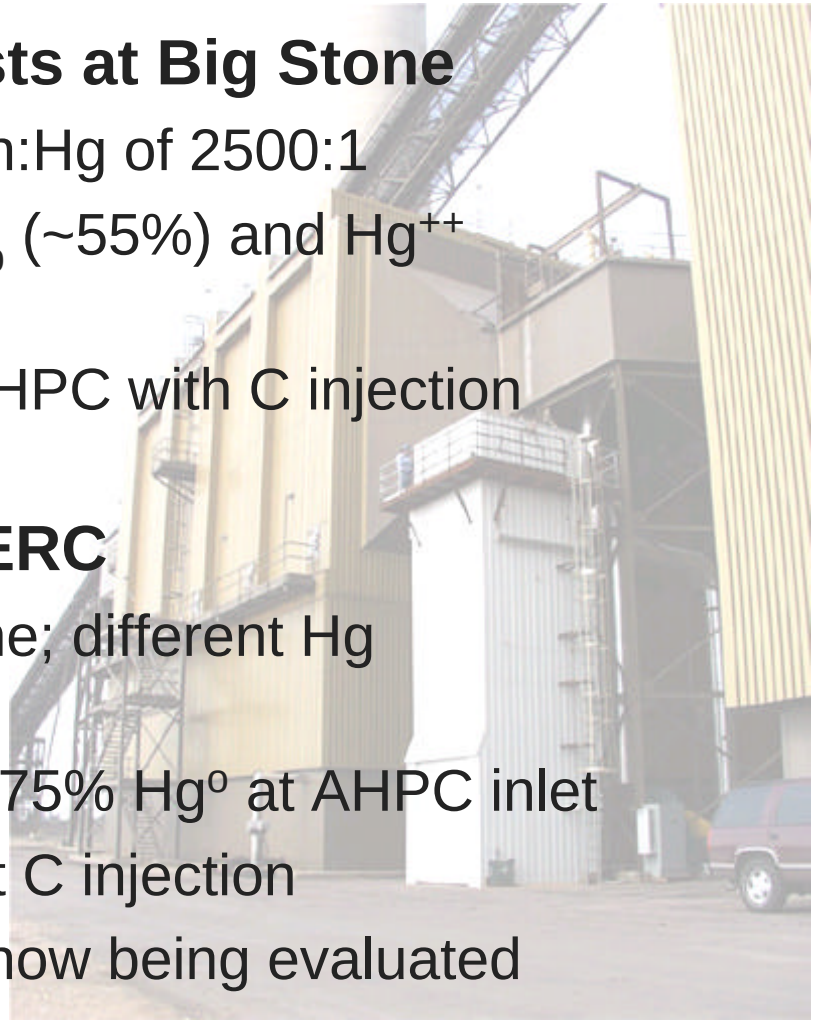
AHPC Slipstream Test Unit at Big Stone Power Plant

AHPC Design Configuration



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

Advanced Hybrid Particulate Collector
Results to Date



- **Preliminary slipstream tests at Big Stone**
  - >90% Hg removal @ carbon:Hg of 2500:1
  - Unusually high levels of Hg_p (~55%) and Hg^{++} (~38%) at AHPC inlet
  - ~49% Hg removal across AHPC with C injection
- **Pilot-scale tests at UNDEERC**
  - Same PRB coal as Big Stone; different Hg speciation
  - <5% Hg_p; 20-25% Hg^{++}, 70-75% Hg^o at AHPC inlet
  - Negligible Hg removal w/out C injection
  - Results of C injection tests now being evaluated

Low-Rank Coal Research Activities
Catalytic Mercury Oxidation

- **URS developing mercury oxidation catalysts**
- **Slip-stream testing at two utility sites**
  - Great River Energy
    - Coal Creek Station (unit 1 of 2)
    - ND lignite w/ESP & Wet Scrubber
  - City Public Service of San Antonio
    - J.K. Spruce Plant
    - Subbituminous coal

URS Pilot-Scale Catalyst Unit

Great River Energy's Coal Creek Station, North Dakota

Sorbent-Based Technologies for Utilities Burning Lignite Coals

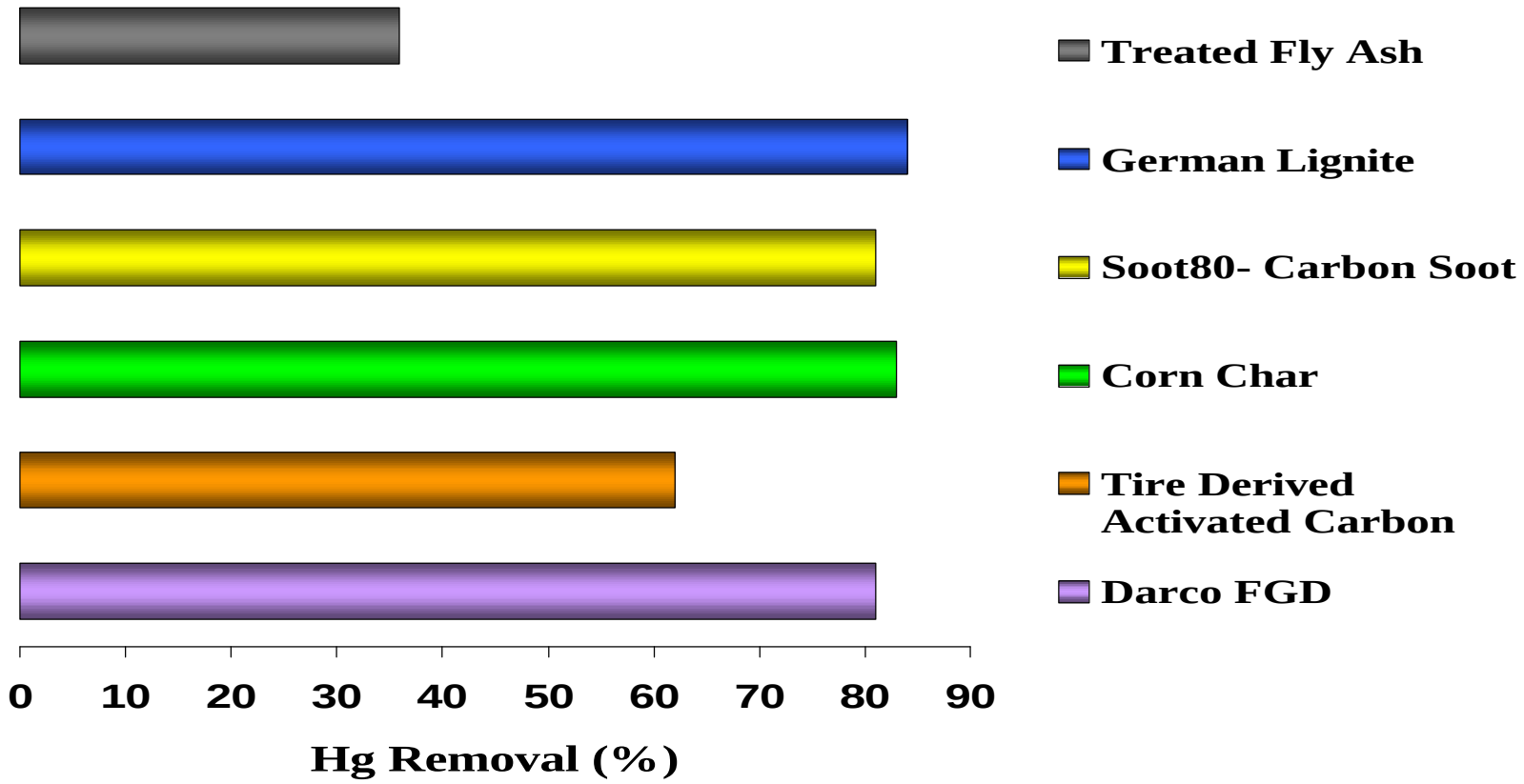
- **Joint project with:**
  - UNDEERC
  - SaskPower
  - EPRI
  - ND utilities
- **Pilot- and full-scale slipstream testing of carbon-based sorbent injection**

SaskPower's 562-MW Lignite-Fired Poplar River Power Plant

APOGEE
Slipstream Evaluation of Hg Sorbents

- **Evaluate alternatives to commercially available AC**
  - Carbons prepared from high-organic sulfur coals, biomass, tires, and fly ash
- **Portable pilot system configured as ESP or baghouse**
- **Testing at**
  - Powerton Generating Station (Midwest Generation)
    - subbituminous coal
  - Valley Power Plant (Wisconsin Electric Power)
    - bituminous coal + coke

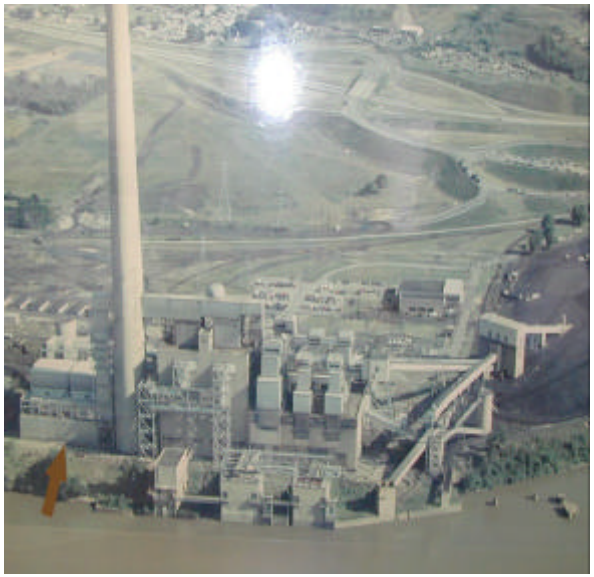
APOGEE
Preliminary Data from Powerton Station



Parametric Testing at Injection rate of 1.5 lb/Mmacf for 20 minutes

POWERSPAN Corp.
Electro-Catalytic Oxidation Technology

- **Barrier discharge reactor to oxidize Hg and other pollutants (SO_2/NOx) for subsequent removal in ammonia scrubber**
- **Fine PM/aerosols captured in wet ESP**
- **Ammonium sulfate/nitrate fertilizer byproduct**



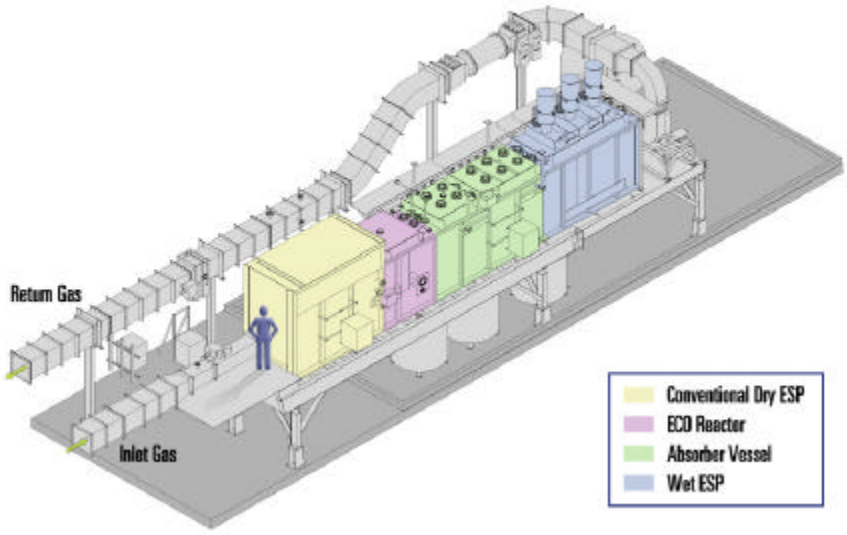
FirstEnergy's R.E. Burger Plant

- **5000 acfm slipstream testing at FirstEnergy's R.E. Burger Plant**

POWERSPAN
Preliminary Results

Emission	Removal
SO_2	>95%
NOx (0.4 lb/mmBtu inlet)	90%
Mercury	85%
PM <3 microns	96-97%
Total PM	99.9%

ECO™ Pilot Unit at FirstEnergy's R.E. Burger Plant



- **High natural Hg^{++} makes it difficult to assess ECO reactor performance**
- **Hg^{o} spiking tests ongoing; sampling difficulties encountered**

CONSOL
Hg/Multi-Pollutant Control

- **Mercury capture with native fly ash at reduced flue gas temperatures**
  - 225º, 260º, and 320º F
- **Alkaline sorbent ($Mg(OH)_2$) injection to remove corrosive SO_3 upstreamof air preheater**
- **4- 6 month long-term test at optimum conditions at Mitchell Station**
  - 288 MW PC-fired unit
  - High Sulfur bituminous coal

Allegheny Energy's Mitchell Station

Impact on By-products Could Be Significant

Fly Ash

- 63M tons / yr generated
- 32% used
- Utilization loss for concrete ≤ $390M impact

FGD By-product

- 25M tons / yr generated
- 19% used
- Utilization loss for wallboard ≤ $135M impact

Fly Ash

FGD By-product

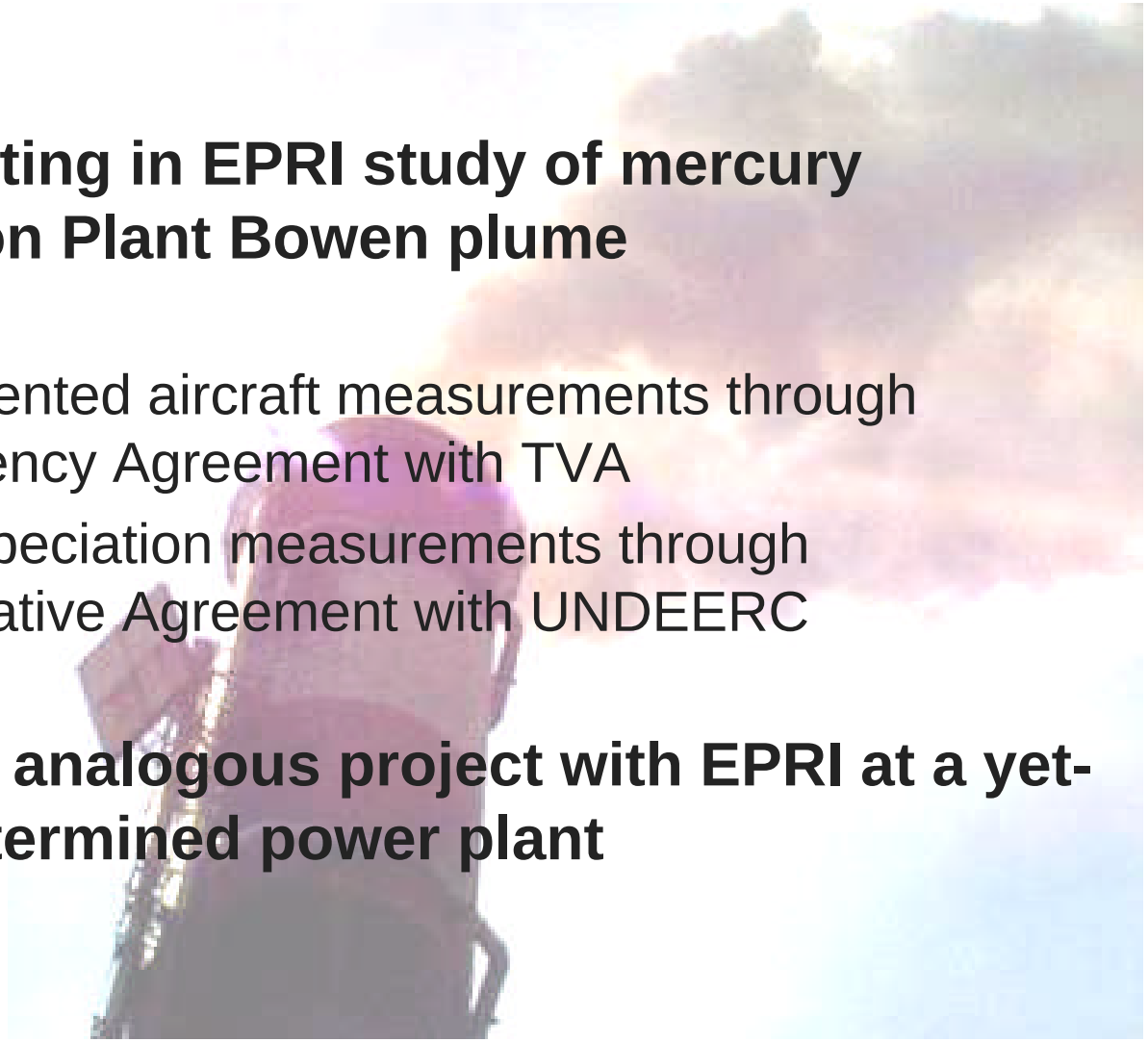
Hazardous Designation of All By-products Would Cost $11 Billion / Year

Coal Combustion Byproduct Research

- **Focus on leaching and volatilization of Hg and other trace metals from coal byproducts;**
  - University of North Dakota Energy and Environmental Research Center
  - CONSOL
  - National Energy Technology Laboratory (Inhouse R&D)
  - EPRI

Fly Ash and Scrubber Solids

Mercury Reactions in Plumes



- **Participating in EPRI study of mercury speciation Plant Bowen plume**
  - Instrumented aircraft measurements through Interagency Agreement with TVA
  - Stack speciation measurements through Cooperative Agreement with UNDEERC
- **Initiating analogous project with EPRI at a yet-to-be-determined power plant**

Key Milestones

Milestone	Date
Issue phase II mercury field testing solicitation	Dec. 2002
Award phase II field testing cooperative agreement	Aug. 2003
Complete 9 month of testing at Alabama Power's Gaston Station	Oct. 2003
Complete slipstream testing of Electro-Catalytic Oxidation process at FirstEnergy's Burger Station	Oct. 2003
Complete leaching tests of coal byproducts from mercury control technology projects	Aug. 2003
Complete 14 month slipstream testing of oxidation catalyst at GRE Coal Creek Station	Feb. 2004

Observations From Field Tests

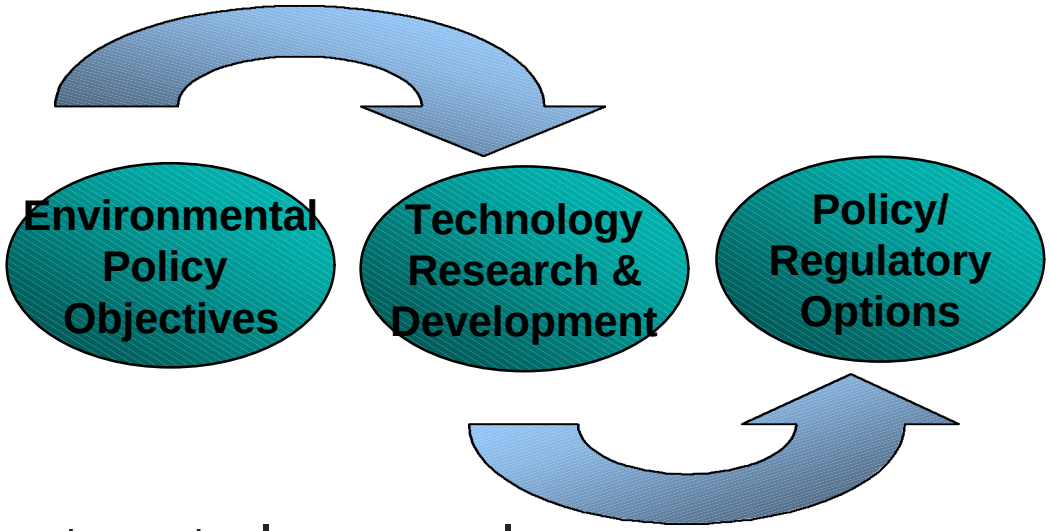
- **Activated carbon removes Hg**
  - Range of effectiveness depends on coal type and plant configuration
- **Many uncertainties remain**
  - Low-rank coals
  - By-product use and disposal
  - Sorbent costs
  - Units equipped with ESPs
  - Downtime for startup

Uncertainties
Mercury Control Technologies

- **Capture effectiveness with low-rank coals**
- **Balance-of-plant impacts**
- **By-product use and disposal**

Policy and Regulatory Implications of R&D

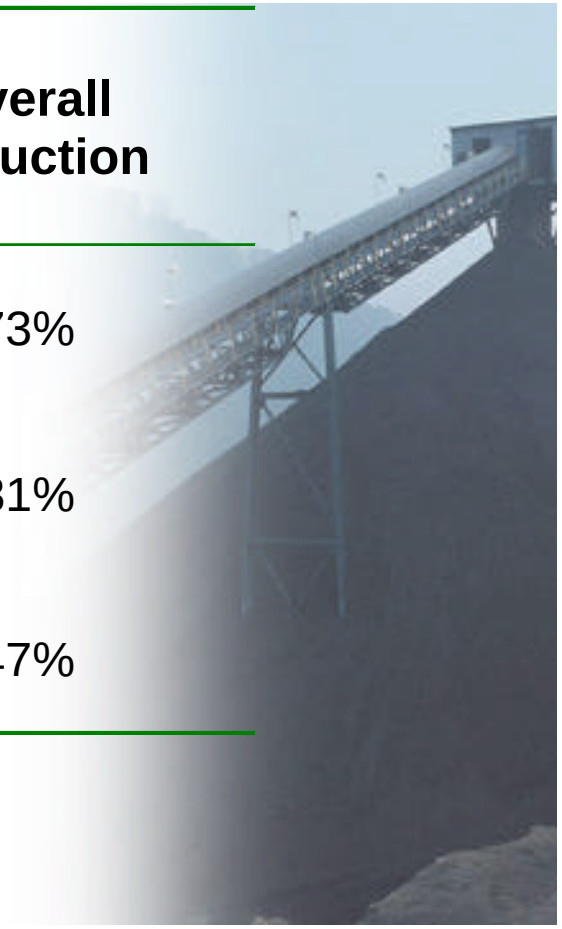
- **Results of research and subsequent cost and performance analyses critical to:**
  - Mercury MACT Interagency Review
  - Administration's Clear Skies Initiative



  - Alternative multi-pollutant control proposals
  - United Nation Environmental Programme (UNEP) Global Mercury Assessment

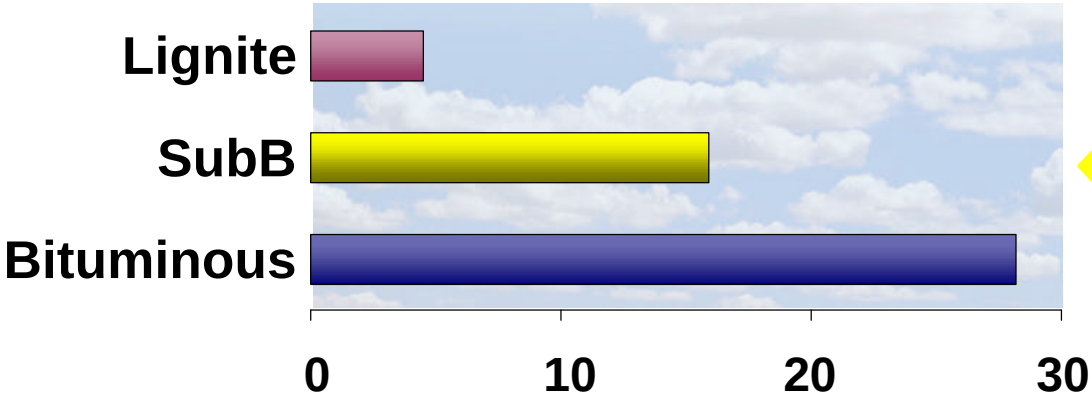
Industry Stakeholder Recommendations

Subcategory	Stack Limit, lb / Tbtu *	Overall Reduction
Bituminous	2.2	73%
Subbituminous	4.2	31%
Lignite	6.5	47%

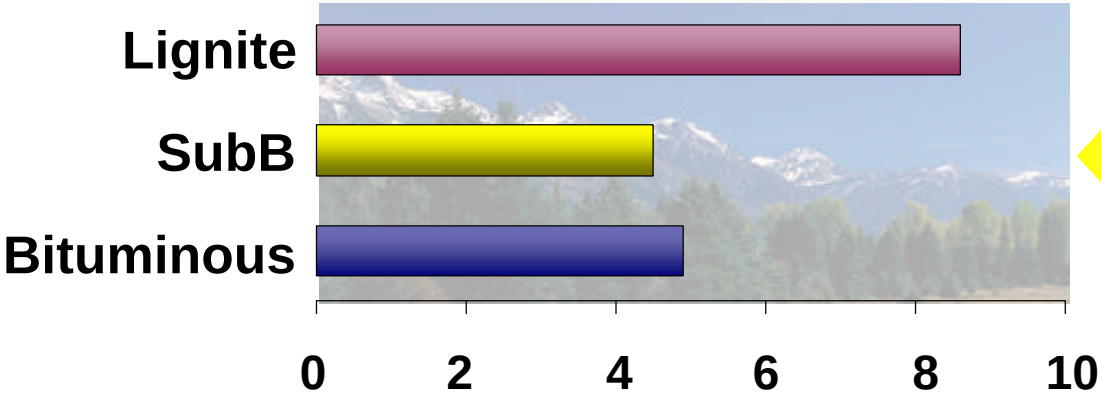


*Limits include only a consideration of fuel variability and no other forms of variability

Mercury Emissions
2000 Data

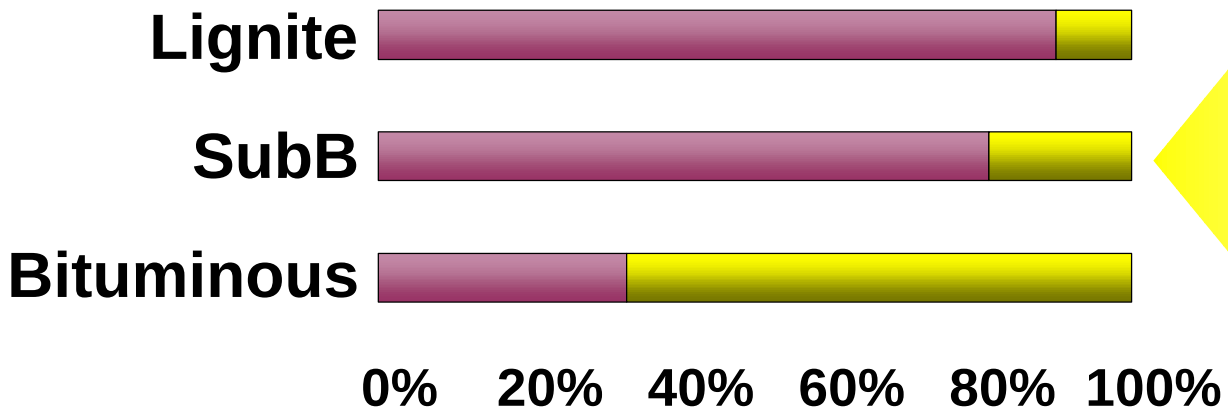


Total US Hg Emissions (tons per year)



Hg Emission Rate (lb per TBtu)

Mercury Chemistry Trends



% Gas Phase Hg Species in Flue Gas*

*Gas phase speciation at exit of a CS-ESP

Elemental Hg

Oxidized Hg

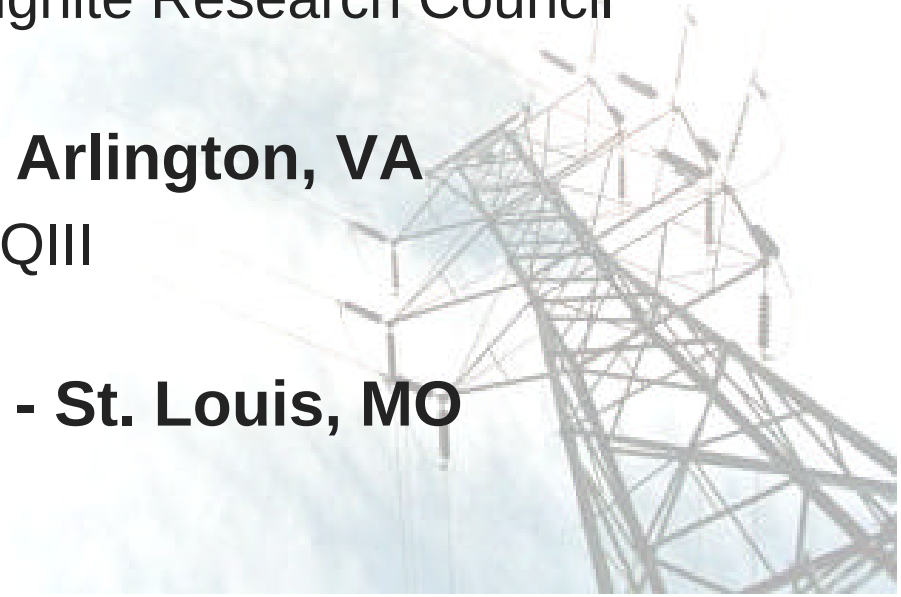
Influences

- **Time**
- **Temperature**
- **Gas composition**
- **Catalysts**

Source: EPA ICR Raw data

Mercury Workshops

- **June 4, 2002 - Washington, DC**
  - Jointly sponsored with EPRI
- **August 27, 2002 - Bismarck, ND**
  - In conjunction with Lignite Research Council
- **September 9, 2002 - Arlington, VA**
  - In conjunction with AQIII
- **November 6-7, 2002 - St. Louis, MO**
  - EPRI Hg Workshop



Mercury Control Technology R&D
Phase II Field Testing Program

- **FY 03 competitive solicitation**
- **Second phase of field testing at commercial coal-fired power plants**
- **Two-month or longer duration testing**

- **Focus on broader suite of boiler configurations and coal-types (e.g., lignite)**

Program Success Built on Partnerships

Jim Kilgroe (EPA), Scott Renninger (NETL), and George Offen (EPRI) discussing strategy

- **NETL works closely with industry, EPA, and other stakeholders in planning and implementing its environmental control technology research program**

For More Information...

- **Visit our website at:**

www.netl.doe.gov/coalpower/environment