

# DOE-NETL's Mercury R&D Program



*American Coal Council*

*Mercury & Multi-  
Emissions Compliance:  
Strategies & Tactics*

*March 26-27, 2003  
Charlotte, NC*

Thomas J. Feeley, III  
National Energy Technology Laboratory



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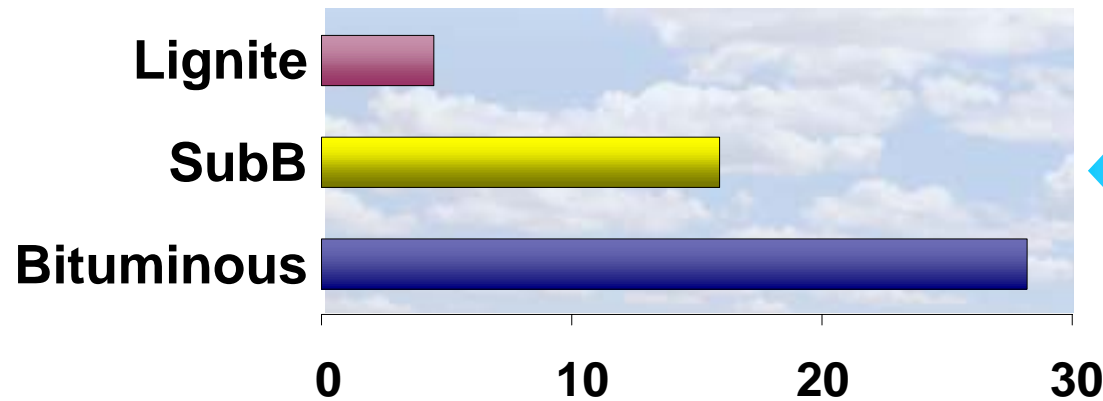
# Presentation Outline

- **Regulatory drivers**
- **Program objectives**
- **Current program**
- **Future plans**

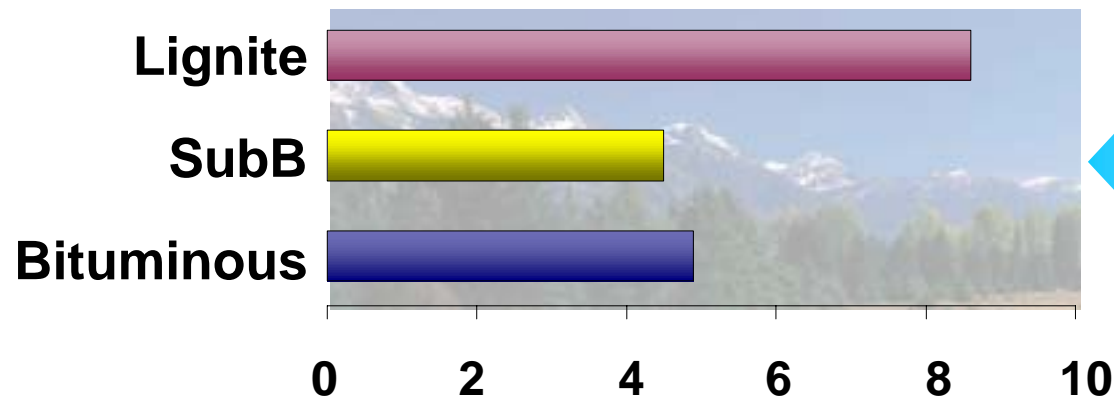


# Power Plant Mercury Emissions

*Coal Plants Emit ~ 48 tons/year*



**Total US Hg Emissions  
(tons per year)**



**Hg Emission Rate  
(lb per TBtu)**

# Potential Mercury Regulations

## MACT Standards

- Likely high levels of Hg reduction
- Compliance: Dec. 2007

## Clean Power Act of 2003

- Re-introduced in Senate (S. 366) by Jeffords (I-VT) on February 12, 2003
- 4-contaminant control
- 90% Hg reduction by 2009

***President Bush  
Announcing Clear  
Skies Initiative  
February 14, 2002***

## Clear Skies Act of 2003

- Re-introduced in House (HR. 999) and Senate (S. 485) on February 27, 2003
- 3-contaminant control
- 46% Hg reduction by 2010
- 70% Hg reduction by 2018
- Hg emission trading



# DOE-NETL Environmental R&D Program

- Driven by current and, more importantly, future environmental regulations and policy decisions
- Develop advanced, cost-effective, control technology
- Provide sound science and technical knowledge



*Skating to where the puck is going...*



# DOE-NETL's Mercury R&D Program

## *Funding Profile*

FY02	FY03	FY04
\$10,000K	\$13,600K	\$13,200K

- **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**

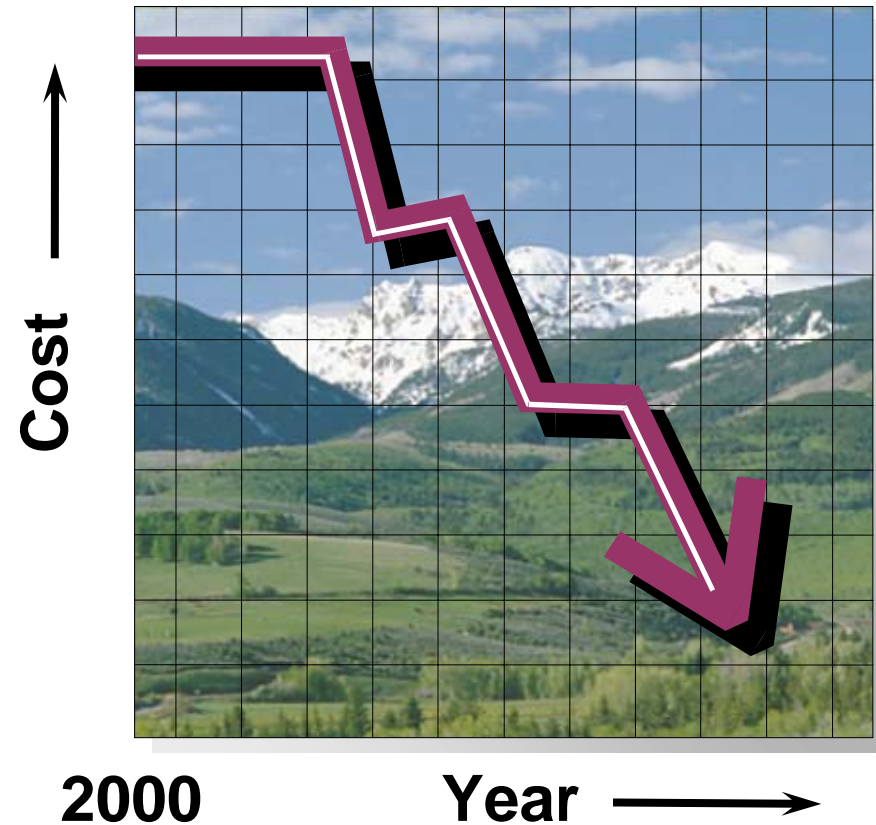


# R&D Goals

## *DOE-NETL Mercury Control Program*

Have technologies ready for commercial demonstration:

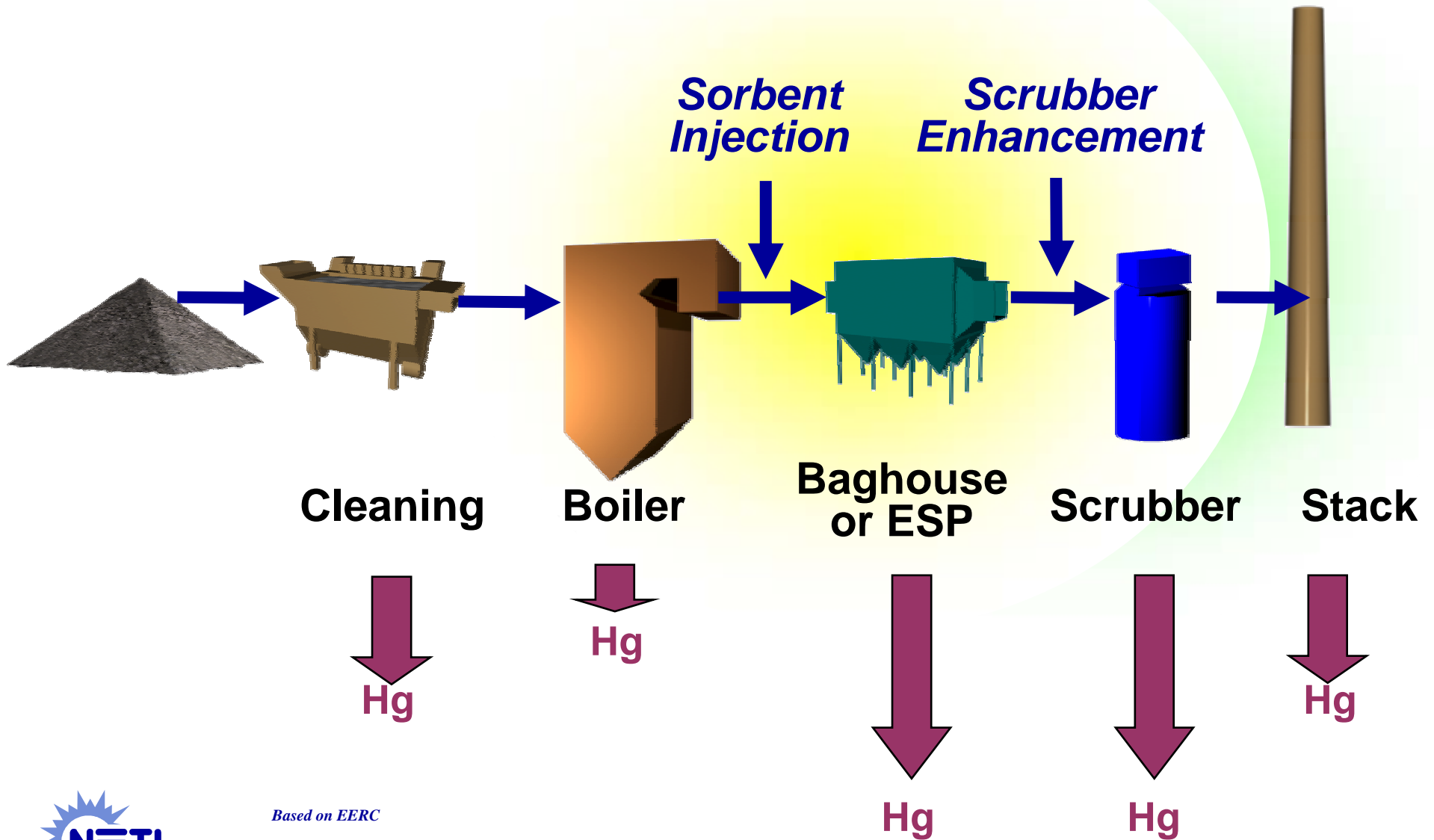
- By 2005, reduce emissions 50-70%
- By 2010, reduce emissions by 90%
- Cost 25-50% less than current estimates



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



# Phase I Field Testing



Based on EERC



# Six Mercury Control Field Tests

Technology / Utility Plant	Test Completion
<p><b>ADA-ES – Sorbent Injection</b></p> <p>Alabama Power – Gaston We Energies – Pleasant Prairie PG&amp;E – Brayton Point PG&amp;E – Salem Harbor</p>	<p>April 2001 November 2001 August 2002 November 2002</p>
<p><b>McDermott-B&amp;W – Enhanced Scrubbing</b></p> <p>Michigan South Central Power – Endicott Cinergy – Zimmer</p>	<p>October 2001 November 2001</p>



# Capturing Mercury Is Difficult!



*Houston  
Astrodome*

## *A Hypothetical Example*

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



# 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



# ADA-ES Field Test Sites



## PG&E – Brayton Point

- 122 MW
- Low-sulfur bituminous coal
- Low-NO<sub>x</sub> burners
- Two ESPs in series

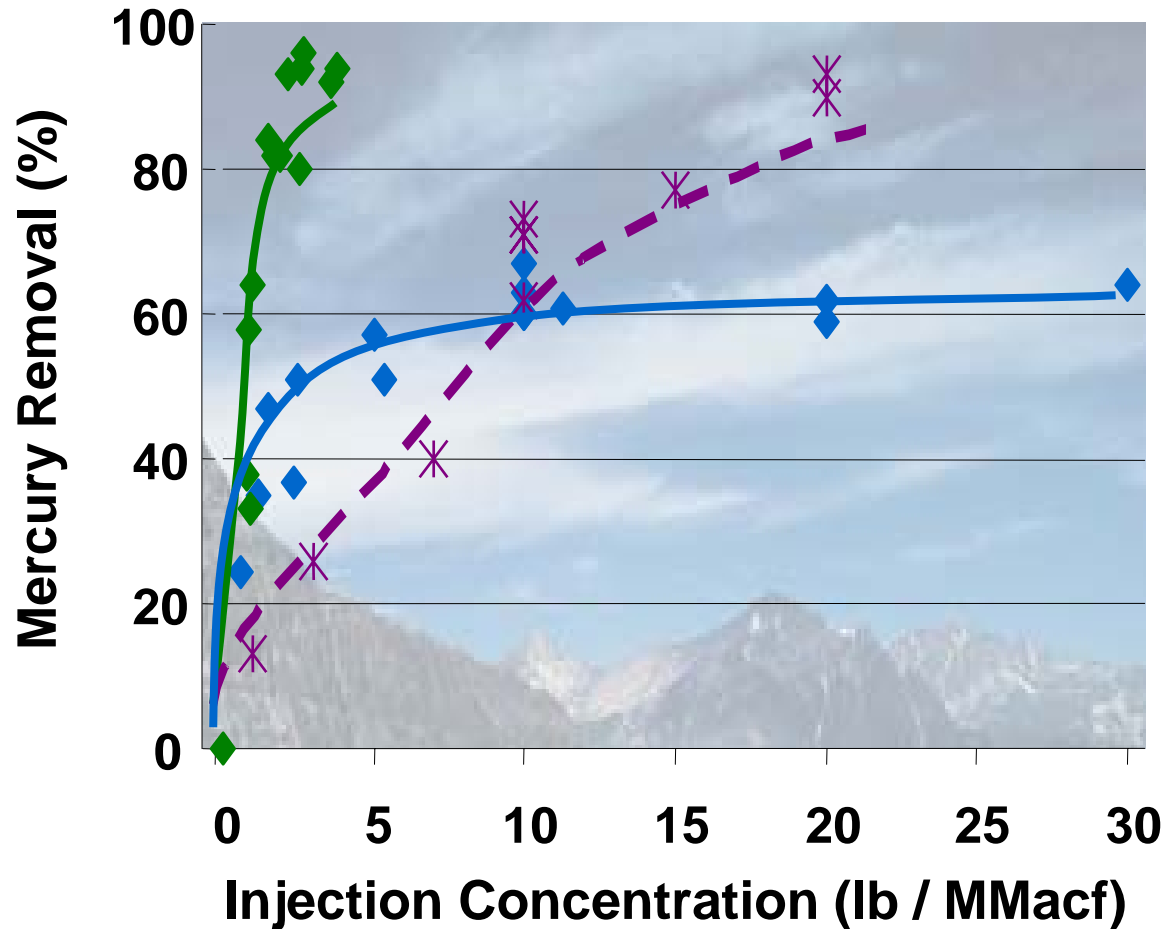
## PG&E – Salem Harbor

- 85 MW
- Low-sulfur South American bituminous coal
- SNCR
- ESP



# ADA-ES Field Test Results

## *Activated Carbon Injection*



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

**Brayton Point:** Bituminous  
coal, ESP

**Pleasant Prairie:**  
Subbituminous coal,  
ESP



# **ADA-ES**

## ***Long-Term Sorbent Injection Testing***

- **Initiate long-term (~12 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**



# McDermott Technology and B&W *Enhanced Mercury Control in Wet FGD*



## Michigan South Central Power's Endicott Plant

- 60 MW
- High-sulfur bituminous coal
- ESP
- Limestone wet FGD

## Cinergy's Zimmer Plant

- 1300 MW
- High-sulfur bituminous coal
- ESP
- Magnesium-enhanced wet FGD



# McDermott Technology and B&W *Enhanced Mercury Control in Wet FGD*

## Wet FGD Mercury Removal, %

MSCP's Endicott Plant		
Mercury Species	Baseline	Reagent*
Total	~ 60%	76%
Oxidized	~ 90%	93%
Elemental	~ (40%)	20%

Cinergy's Zimmer Plant		
Mercury Species	Baseline	Reagent*
Total	~ 45%	51%
Oxidized	~ 90%	87%
Elemental	~ (20%)	(41%)

\*Reagent feed results during two-week verification testing.





# Advanced Mercury Control Concepts

- **Apogee Scientific**

- Advanced Hg sorbents

- **CONSOL**

- Multi-pollutant control for Hg, SO<sub>2</sub>, acid gases

- **UNDEERC**

- Hybrid particulate control system

- **Powerspan**

- Multi-pollutant control for Hg, SO<sub>2</sub>, NO<sub>x</sub>, particulates, acid gases

- **Southern Research Institute**

- Calcium-based additives to control Hg

- **URS Group**

- Catalyst to convert elemental to oxidized Hg

**Designed to Achieve  $\geq 90\%$  Hg Removal**



# UNDEERC

## *Advanced Hybrid Particulate Collector*

- **9,000 acfm slipstream testing at Otter Tail Power**
  - PRB coal
  - >90% Hg removal @ C:Hg of ~1.5 lb/mmacf
  - Unusually high levels of Hg<sub>p</sub> (~55%) and Hg<sup>++</sup> (~38%) at AHPC inlet
- **200 acfm pilot-scale testing**
  - Same PRB coal as Big Stone
  - <5% Hg<sub>p</sub>; 20-25% Hg<sup>++</sup>, 70-75% Hg<sup>o</sup>
  - Negligible Hg removal w/out C injection
  - Currently evaluating C inject results



***AHPC Slipstream Test Unit  
at Big Stone Power Plant***



# URS Group

## *Catalytic Mercury Oxidation for Low-Rank Coals*

- 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*



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# **Southern Research Institute**

## *Pilot-testing with Calcium-Based Sorbents and Oxidizing Agents*

- **Evaluate alternatives to commercially available activated carbons**
  - Sorbents prepared with calcium-based products such as hydrated lime and silica-modified calcium could provide for the simultaneous removal of mercury and SO<sub>2</sub>
  - Oxidizing agents could enhance mercury capture
- **Three-year test program at SRI using 1 MW pilot plant began in September 2001**



# **Powerspan**

## *Electro-Catalytic Oxidation Technology*

- **Barrier discharge reactor to oxidize Hg and other pollutants (SO<sub>2</sub>/NO<sub>x</sub>) for subsequent removal in ammonia scrubber**
- **Fine PM/aerosols captured in wet ESP**
- **Ammonium sulfate/nitrate fertilizer byproduct**
- **5000 acfm slipstream testing at FirstEnergy's R.E. Burger Plant**



*FirstEnergy's R.E. Burger Plant*



# CONSOL

## *Mercury/Multi-Pollutant Control*

- Mercury capture with native fly ash at reduced flue gas temperatures (320° to 220°F)
- Alkaline sorbent ( $\text{Mg}(\text{OH})_2$ ) injection to remove corrosive  $\text{SO}_3$  upstream of 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*



# 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**



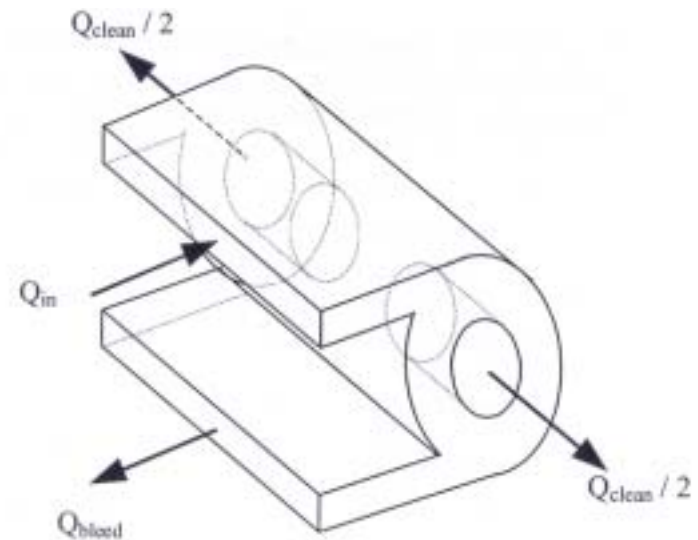
***SaskPower's 562-MW Lignite-Fired  
Poplar River Power Plant***



# LSR Technologies

## *Advanced ElectroCore Particulate Collector*

- **Combination of activated carbon injection with ElectroCore particulate collector**
- **Pilot-scale testing conducted at Southern's E.C. Gaston Plant**
- **Preliminary results indicate 90% mercury removal with ACI feed rate of 7 lb/MMacf**



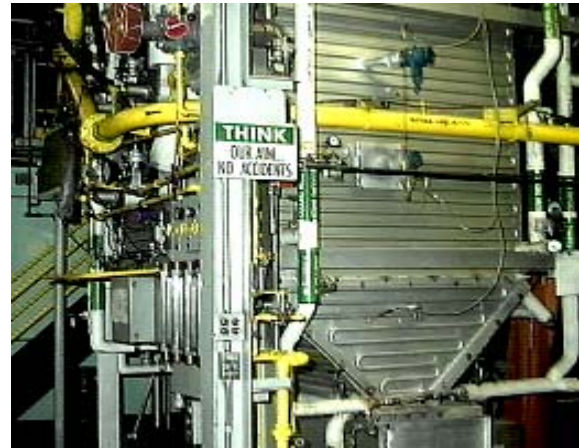
**Schematic of ElectroCore cylindrical separator**





# NETL's Inhouse R&D Activities

- **THIEF Process** - Capture Hg on semi-combusted coal extracted from furnace and re-injected downstream of air preheater
- **GP-254 Process** - Uses 253.7-nanometer ultraviolet radiation to increase fraction of oxidized Hg



**NETL's  
500#/hr  
Coal  
Combustion  
Pilot Unit**



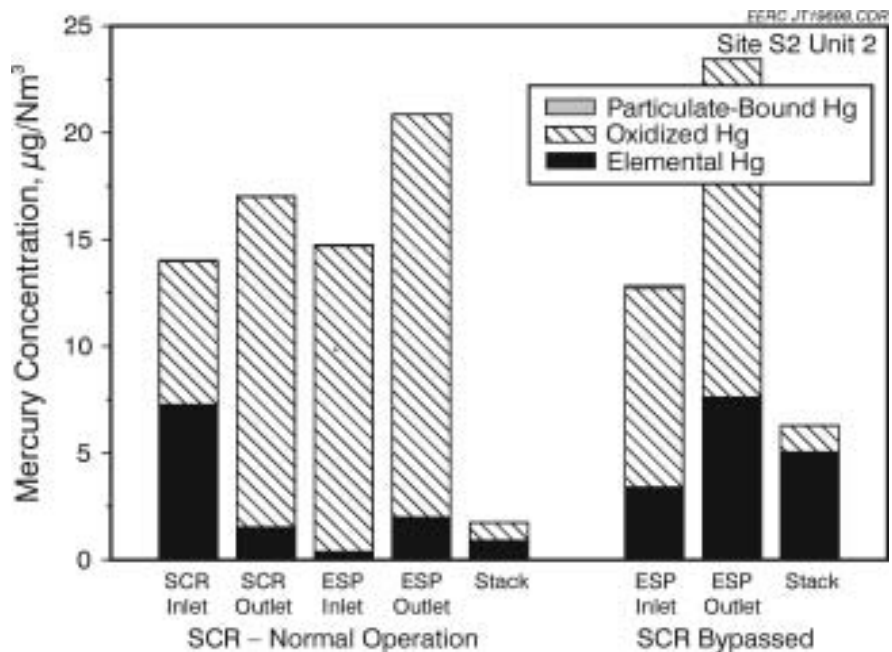
**Dr. Evan Granite, co-inventor of  
GP-254 Process**



# UNDEERC

## *Effect of NO<sub>x</sub> SCR on Mercury Speciation*

- Co-funded with EPA and EPRI
- 2001 field testing at four plants with NO<sub>x</sub> SCR
  - Two plants showed significant oxidation
  - Two plants showed minimal oxidation
- Testing continued in 2002 and 2003

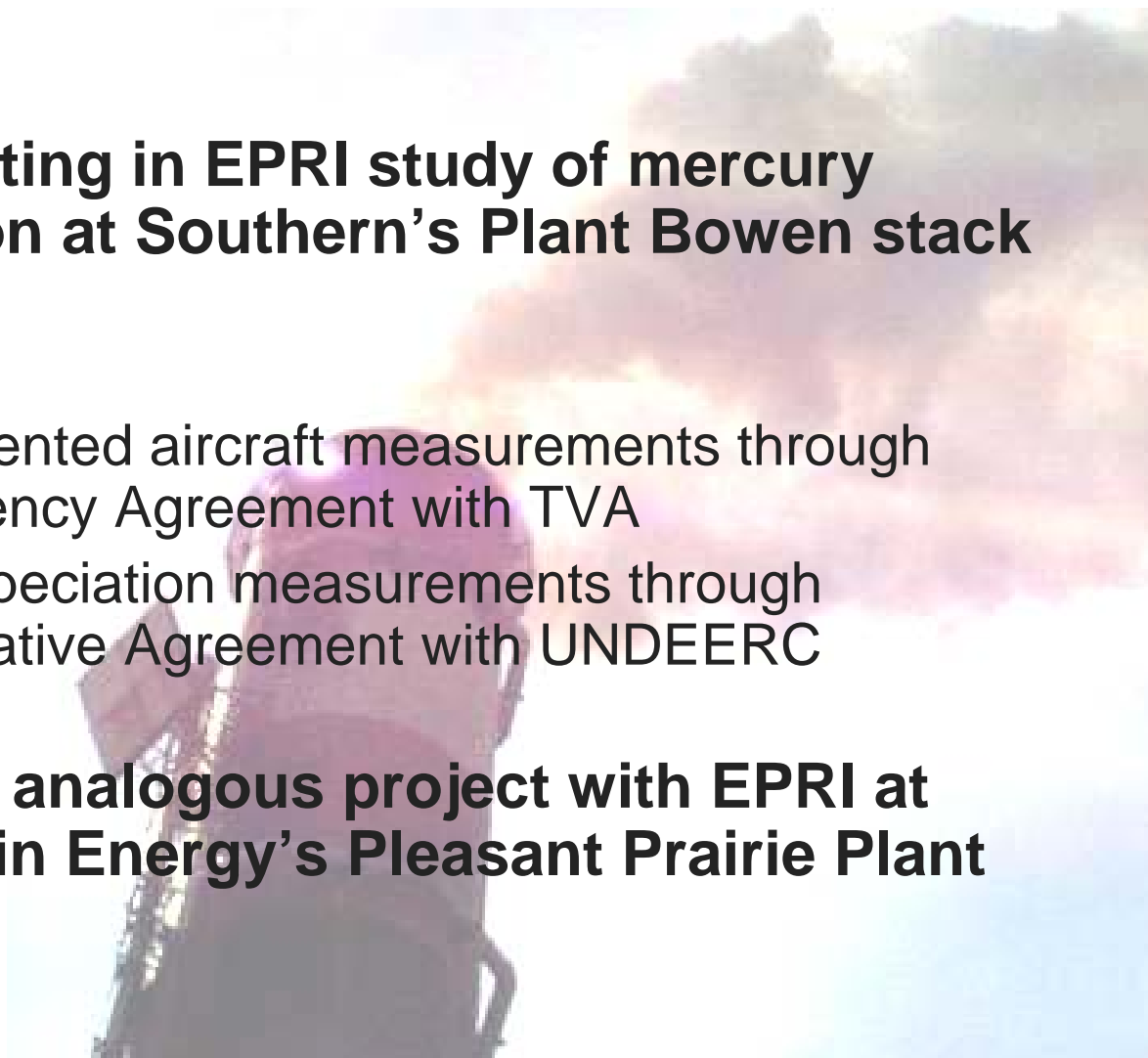


Site S2 OH Test Results  
per EPRI Report 1005400 dated December 2002



## Mercury Reactions in Plumes

- **Participating in EPRI study of mercury speciation at Southern's Plant Bowen stack plume**
  - Instrumented aircraft measurements through Interagency Agreement with TVA
  - Stack speciation measurements through Cooperative Agreement with UNDEERC
- **Initiating analogous project with EPRI at Wisconsin Energy's Pleasant Prairie Plant**



# Coal Combustion Byproduct Research

- **Characterization of Hg (and other trace metals) leaching and volatilization 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*

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



# New Mercury Control R&D Projects for 2003

General Electric Energy and Environmental Research Corp – Two-year field evaluation using OFA and coal reburn to optimize mercury removal with an ESP at Western Kentucky Energy's Green Power Station

CONSOL – Conduct mercury speciation field testing at several plants equipped with both SCR and wet FGD

Reaction Engineering – Conduct a six-month pilot-scale mercury speciation test for several NOx SCR catalysts at AEP's Rockport Power Plant which burns a PRB coal

UNDEERC – Conduct three-year laboratory and field testing evaluation of the potential release of mercury and other air toxics associated with the disposal and commercial use of coal utilization by-products



# Observations From Field Tests

- **Activated carbon removes Hg**
  - Range of effectiveness depends on coal type and plant configuration
- **Many uncertainties remain**
  - Capture effectiveness with low-rank coals
  - Sorbent feed rate and costs
  - By-product use and disposal
    - At Pleasant Prairie, LOI increased from 0.6% to 2.5-3.5% at 10 lb/MMacf
  - Need for fabric filter for units equipped with ESP
  - Balance-of-plant impacts



# Mercury Control Technology R&D

## *Phase II Field Testing Program*

- Targeted solicitation issued Feb. 5, 2003: Closes April 7, 2003 and Jan. 29, 2004
- Second phase of field testing at commercial coal-fired power plants
  - Activated carbon/sorbent injection
  - Enhance capture across FGD
  - Oxidation technology
  - Novel concepts
- One-month or longer duration testing at optimum conditions with focus on broader suite of boiler configurations and coal-types (e.g., lignite)



# Policy and Regulatory Implications of R&D

- **Results of research and subsequent cost and performance analyses critical to:**

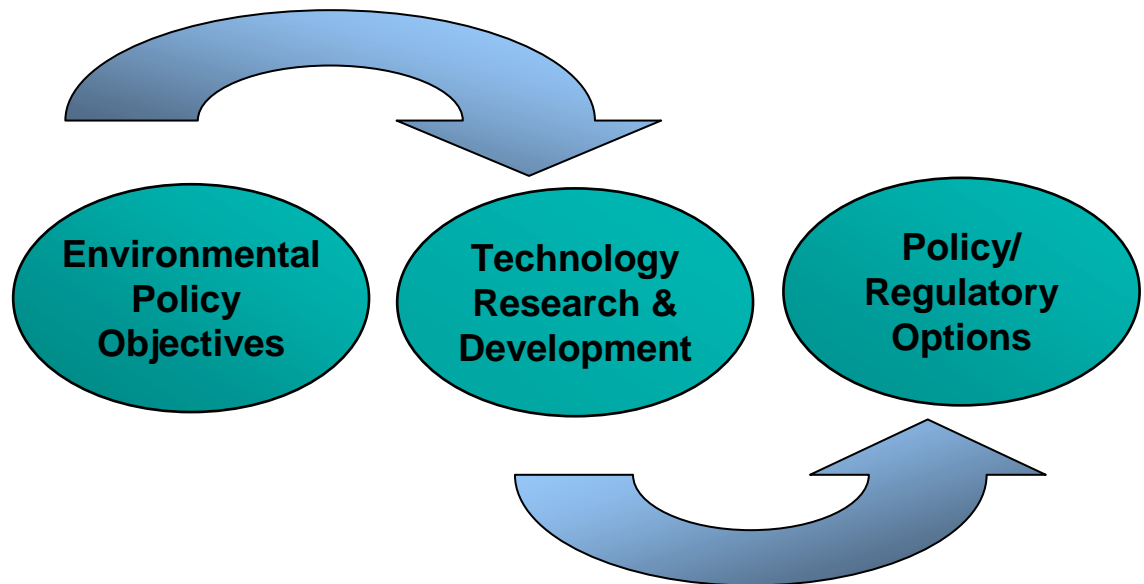
- Hg and HAP Reports to Congress

- Hg MACT Interagency Review

- Administration's Clear Skies Initiative

- Alternative multi-pollutant control proposals

- United Nation Environmental Programme (UNEP) Global Mercury Assessment





# Program Success Built on Partnerships



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

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



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## Upcoming Hg Meeting

- **DOE-NETL Mercury Control Technology R&D Program Review Meeting**
- **August 12-13, 2003**
- **Pittsburgh, PA**
- **Pittsburgh Airport Hyatt**



# DOE-NETL Environmental and Water Resources Home Page



- *To find out more about DOE-NETL's Hg R&D activities visit us at:*

**[www.netl.doe.gov/coalpower/environment](http://www.netl.doe.gov/coalpower/environment)**

