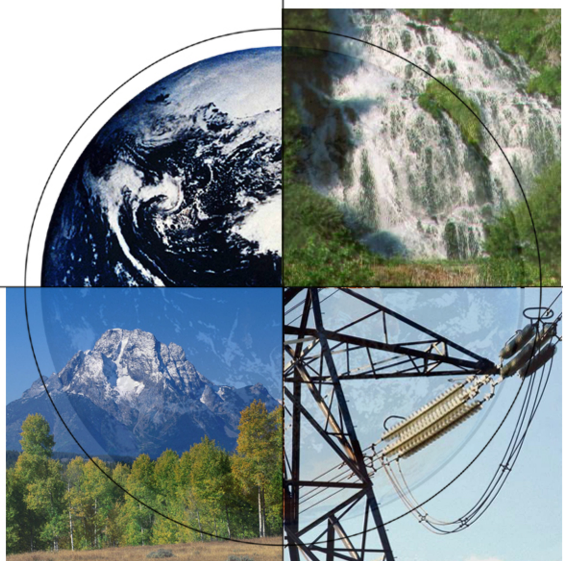
DOE's Hg Control Technology and Related Coal Utilization Byproducts Characterization Research



Presented to
Indiana Office of Air Quality
Mercury Workshop

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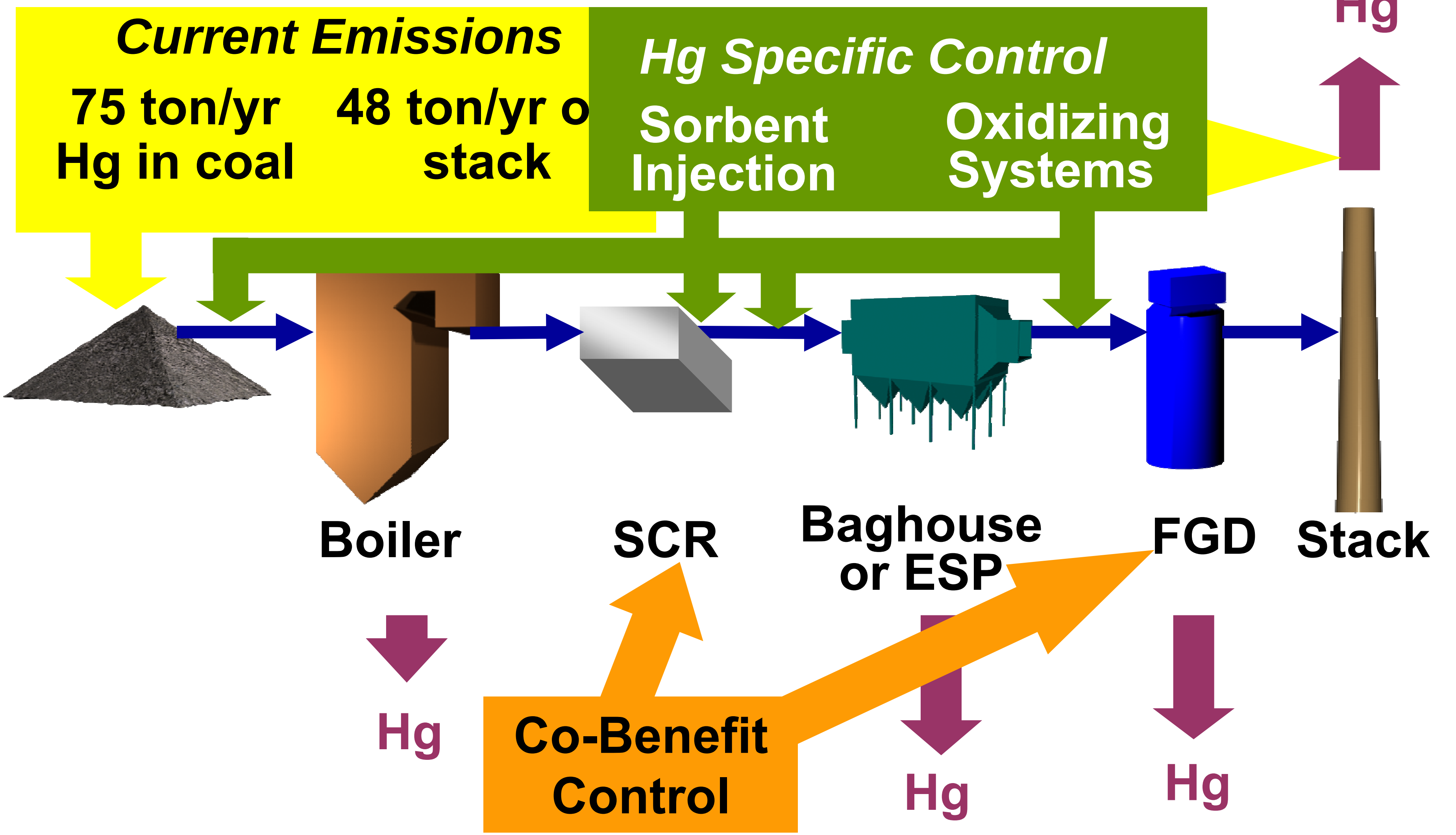
Outline

- DOE/NETL’s Hg control technology program
- Characterization of fly ash
- Characterization of FGD solids
- Summary/conclusion

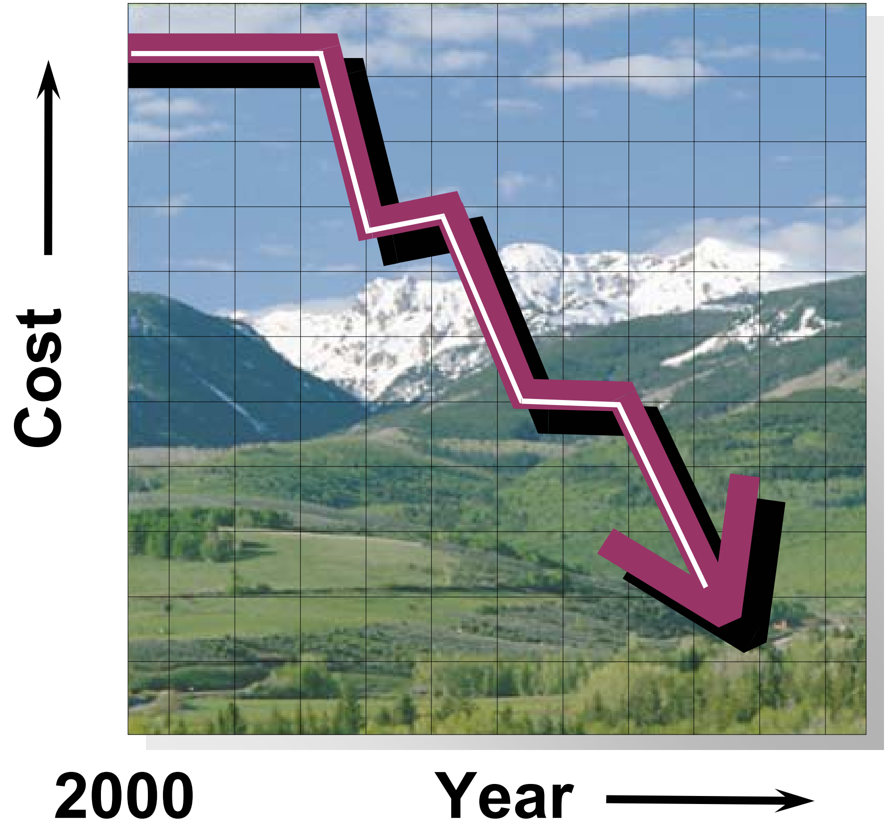
Power Plant Mercury Control



Mercury Field Testing Program

Objectives

- **Have technologies ready for commercial demonstration by 2007 for all coals**
- **Reduce emissions 50-70%**
- **Reduce cost by 25-50% compared to baseline cost estimates**



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

DOE/NETL 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

DOE/NETL Phase II Mercury Control Field Testing Technology Matrix

Coal Rank	Cold-side ESP (low SCA)	Cold-side ESP (medium or high SCA)	Hot-side ESP	TOXECON	ESP/FGD	SDA/FF
Bituminous	Miami Fort 6 Yates 1&2	Lee Buck Portland Sevier Monroe	Buck	Independence Gavin	Yates 1 Yates 1 Conesville Conesville	
Subbituminous	Crawford	Meramec Dave Johnston	Council Bluffs Louisa Will County			
Lignite (North Dakota)		Leland Olds 1 Leland Olds 1 Stanton 1			Milton Young	Antelope Valley 1 Stanton 10 Stanton 10
Lignite (Texas)					Monticello Monticello Monticello	
Blends		St. Clair		Big Brown		Holcomb

Sorbent Injection

Oxidation Additive

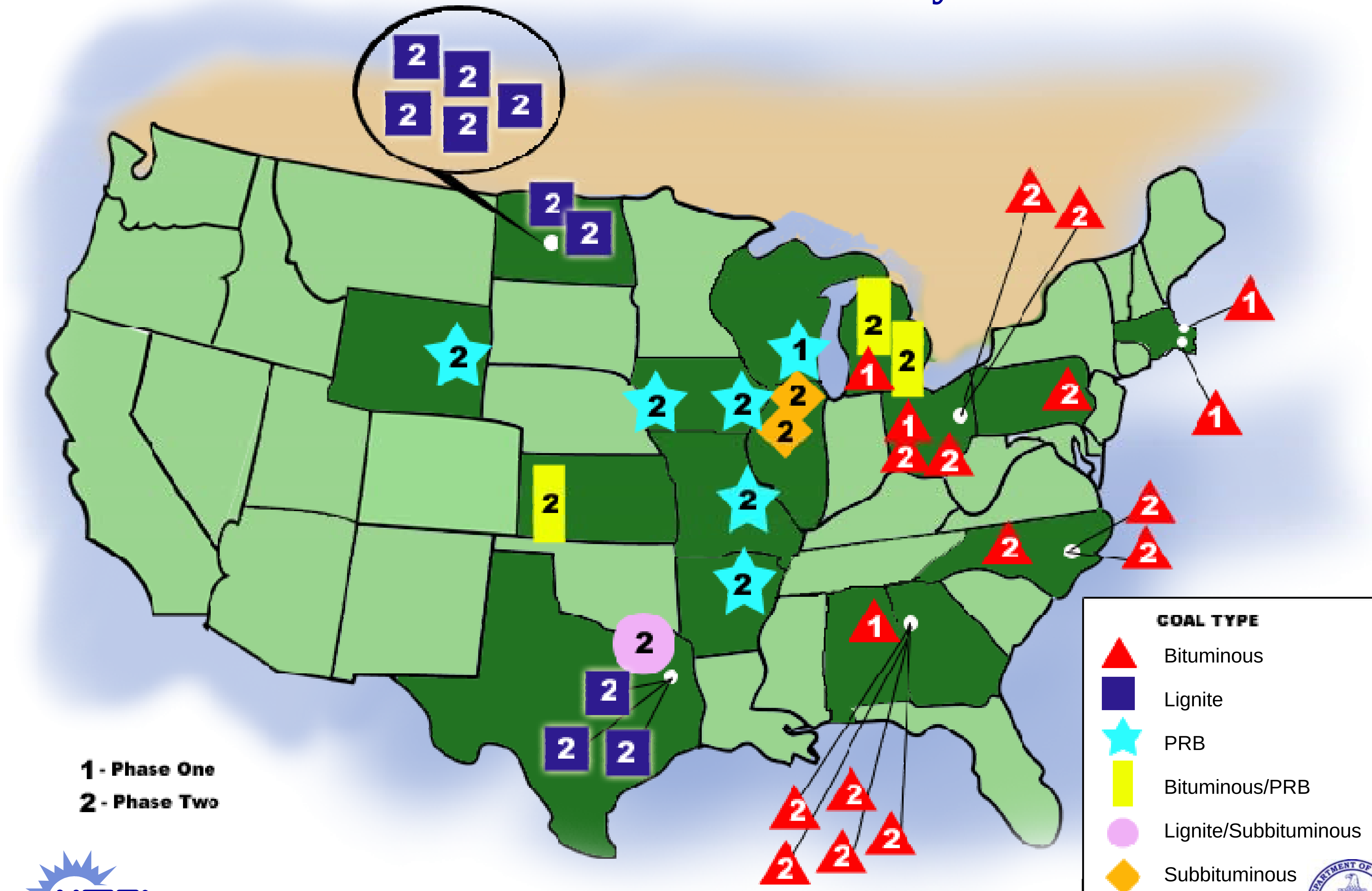
Chemically-treated sorbent

Sorbent Injection & Oxidation Additive

Oxidation Catalyst

Other – MERCAP, FGD Additive, Combustion

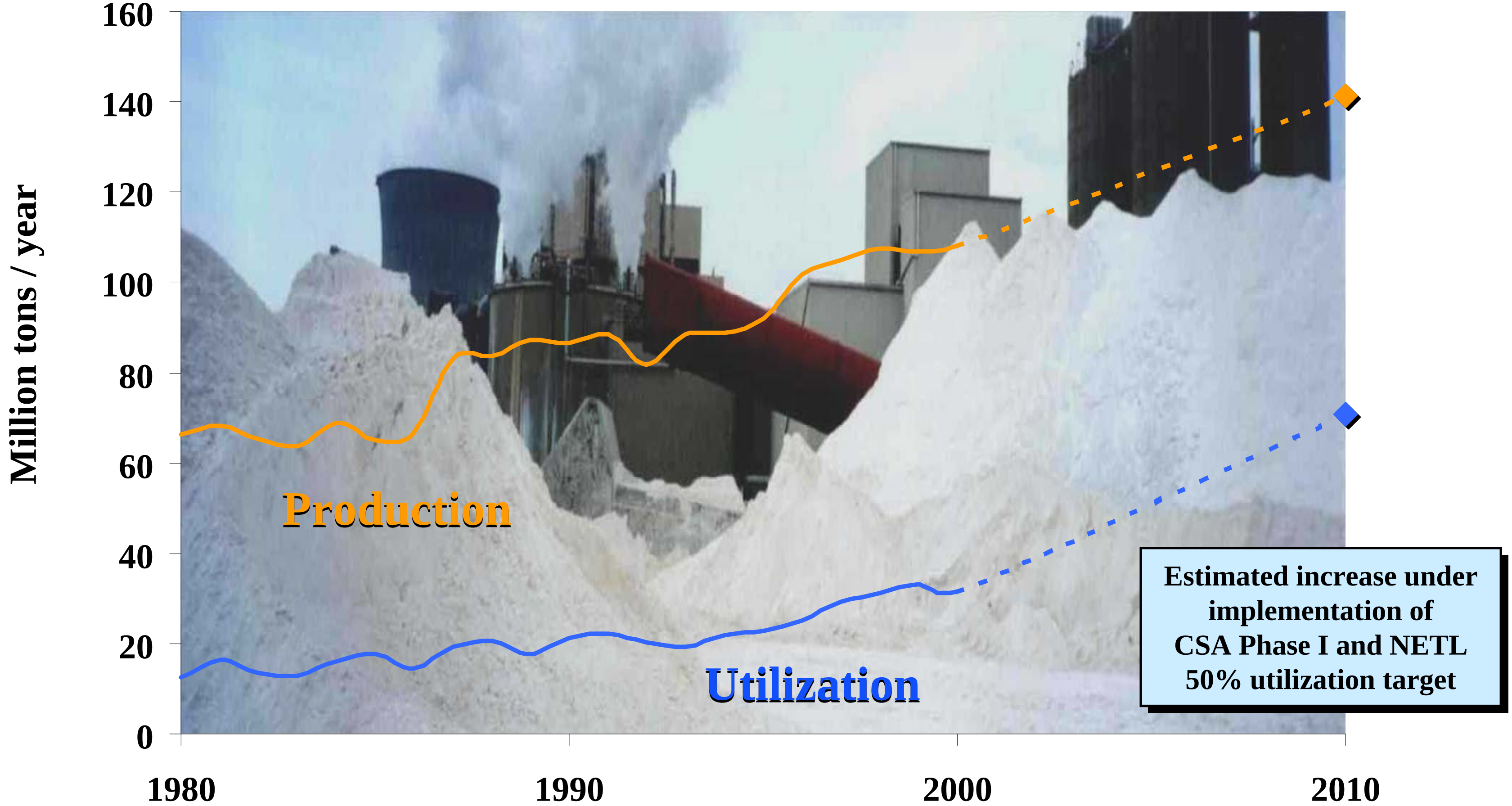
DOE/NETL Phase I & II Mercury Field Sites



What are CUBs?

- **Coal Utilization Byproducts (a.k.a. CCBs, CCPs, CCW, FFCW, CCR ...)**
- **Utilization includes:**
  - Combustion
  - Gasification
  - Hybrid systems

DOE/NETL Goal: Increase CUB Utilization to 50% by 2010



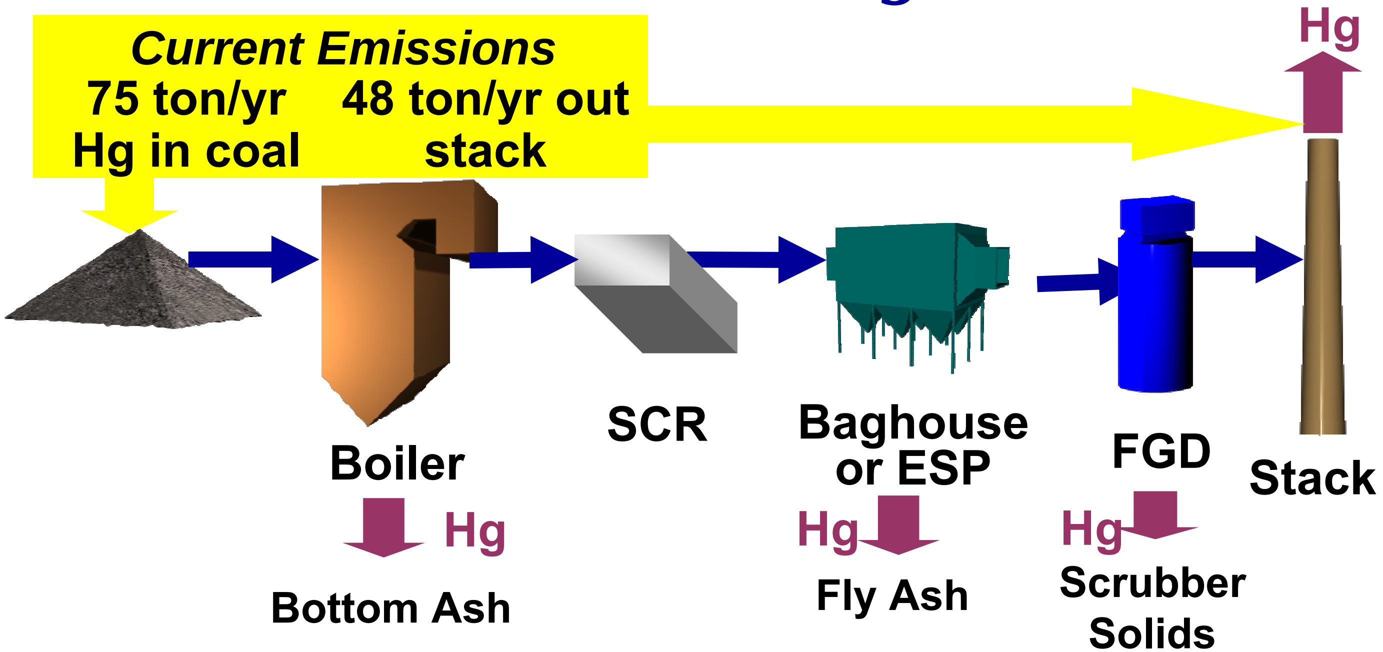
Source: USGS, Historical Statistics for Mineral Commodities in the United States, May 2002

4 Key Challenges to Increased CUB Use

- Installation of additional FGD to meet CSI or CAIR would increase volume of scrubber solids
- Installation of additional advanced combustion technology and SCR to meet CSI or CAIR could increase UBC and NH_3 in fly ash
- Use of AC injection for Hg control could negatively impact fly ash utilization due to increased carbon content
- Increased scrutiny of CUBs due to transfer of Hg from flue gas to fly ash and scrubber solids

Impact of Regulation on Coal Byproducts

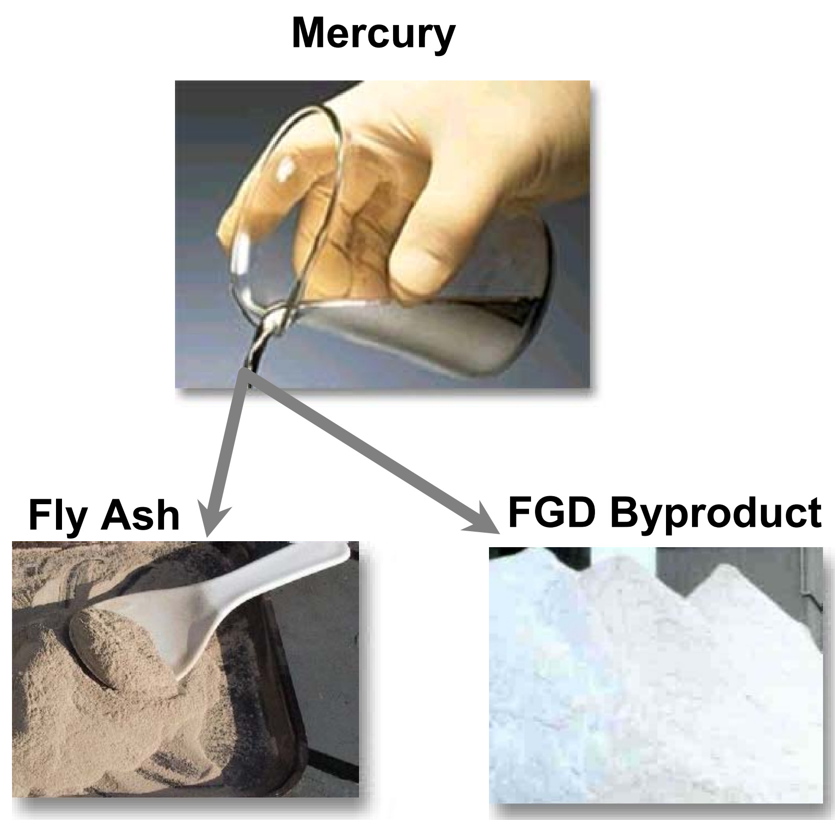
Where Does Hg Go?



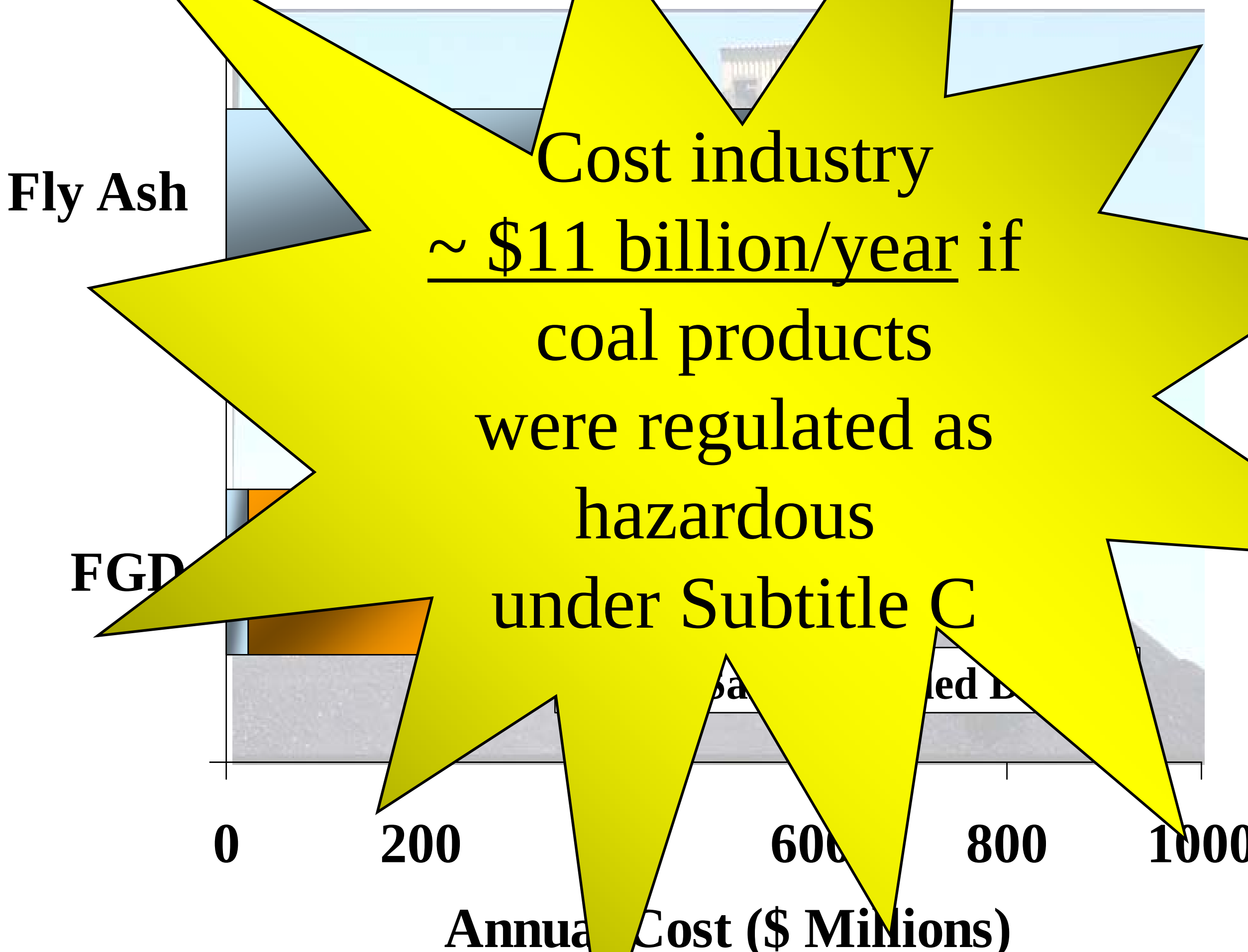
% Hg Reduction	Tons/Yr Hg Reporting to Byproducts
BAU	27
70	61
80	65
90	70

Why are We Concerned About Fate of Hg?

- **Impact on environment?**
  - Does Hg removed from flue gas get back into environment?
- **Impact on disposal and reuse options?**



Potential Impact of Regulations on Coal Products



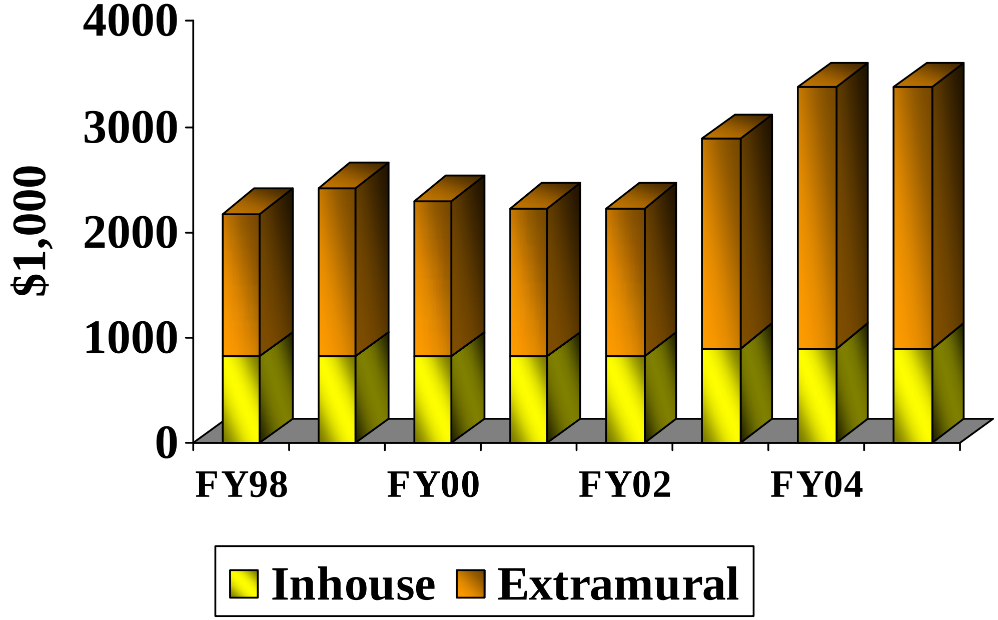
Cost industry
<u>~ $11 billion/year</u> if
coal products
were regulated as
hazardous
under Subtitle C

Total cost impact of lost sales and added disposal requirements

DOE/NETL CUB Research Funding

- Over $22 million from FY98 – FY05 under IEP Program
- Additional $22 million for CUB technology demonstration under DOE's clean coal program

CUB Research Funding under IEP program



What is DOE/NETL Doing?

Project Title	Lead Organization
CUB Analysis from ACI Mercury Control Field Testing	ADA-ES and Reaction Engineering
CUB Analysis from Wet FGD Reagent Hg Field Testing	Babcock & Wilcox
Characterization of Coal Combustion By-Products for the Re-Evolution of Hg into Ecosystems	CONSOL Energy
Hg and Air Toxics Element Impacts of Coal Combustion By-product Disposal and Utilization	UNDEERC
Effect of Hg Controls on Wallboard Manufacture	CBRC and TVA
Fate of Hg in Synthetic Gypsum Used for Wallboard Production	USGypsum
CUB Batch Characterization and Interlaboratory Comparison	NETL In-house
Hg and Metals Stability in CUBs	NETL In-house
Hg Capture and Potential Release from FGD Products	NETL In-house

Characterization of Hg in CUBs from Activated Carbon Injection Projects

- **E. C. Gaston (AL) - Bituminous**
  - ESP + COHPAC FF for particulate control
- **Brayton Point (MA) – Bituminous**
  - 2 ESPs in series
- **Salem Harbor (MA) – Bituminous**
  - ESP: 474 SCA
- **Pleasant Prairie (WI) – PRB**
  - ESP: 468 SCA

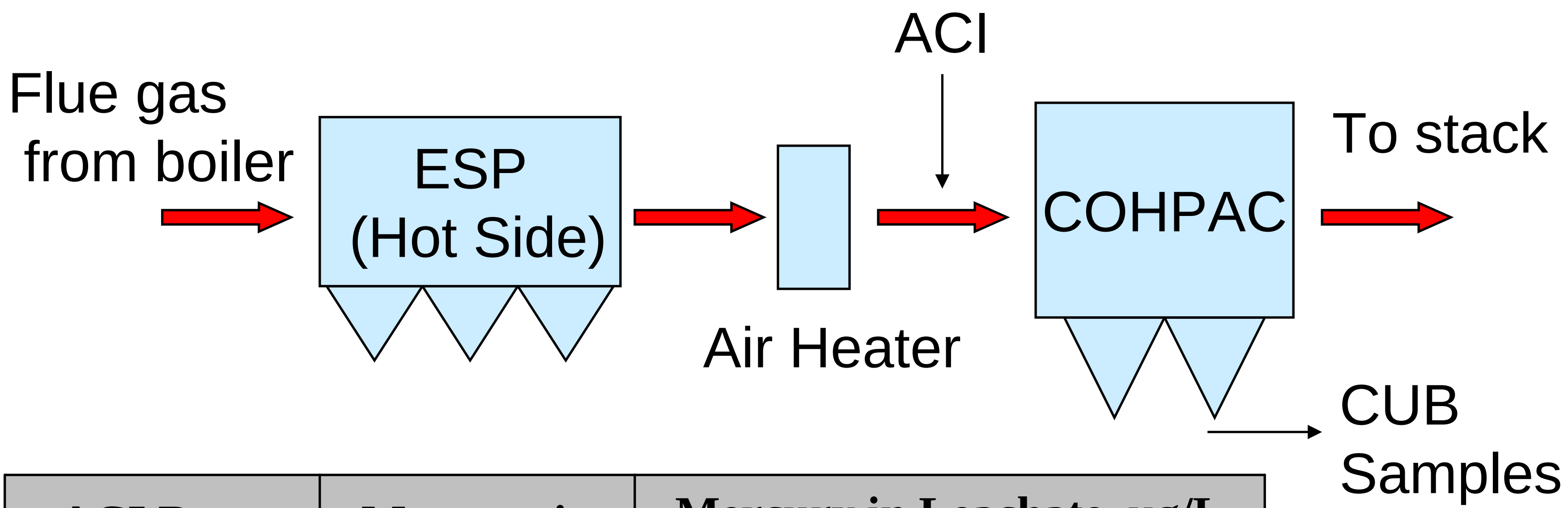
Activated Carbon Storage Silo

Impact of ACI on Fly Ash Mercury Concentrations

	Alabama Power E.C. Gaston	WeEnergies Pleasant Prairie	PG&E Brayton Point	PG&E Salem Harbor
APCD Configuration	Hot-side ESP and COHPAC	Cold-side ESP	Cold-side ESP (two)	Cold-side ESP & SNCR
Coal Rank	Bituminous	Subbituminous	Bituminous	Bituminous
Coal Ash, %	14.78	5.25	10.76	4.15
Coal Hg, ppm	0.146	0.156	0.068	0.063
Baseline Ash Hg, ppm	0.2 − 2	< 0.5	<0.5	NA
ACI Ash Hg, ppm	10 − 50	0.5 − 5	0.2 – 1.4	0.1 – 0.7

Results from DOE/NETL 2001-02 activated carbon injection field tests

Results: E.C. Gaston Plant

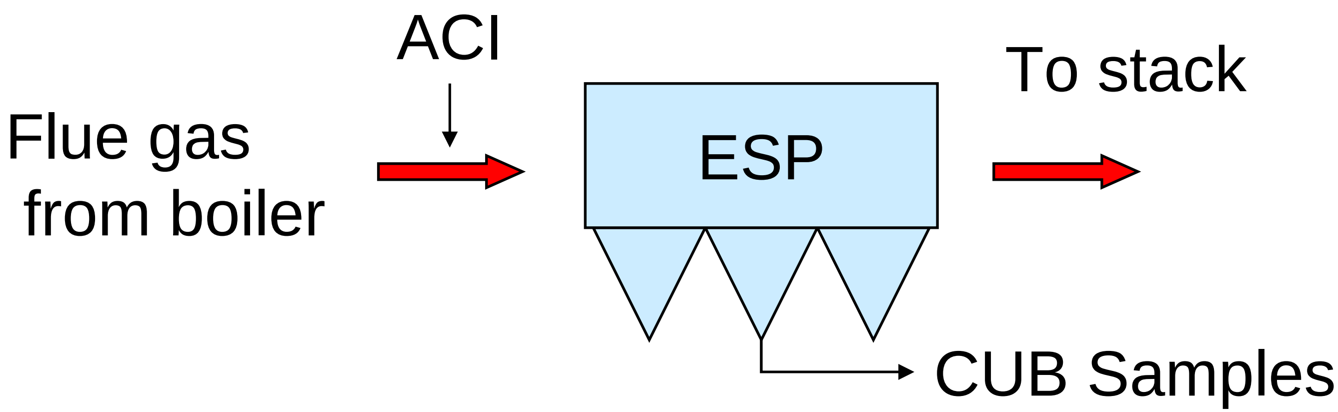


ACI Rate, lb/MMacf	Mercury in Solid, µg/g	Mercury in Leachate, µg/L	
		TCLP	SGLP
1.5	10 – 50	0.01	BDL*
1.5	10 – 50	N/A+	BDL
1.5	10 - 50	BDL	BDL

* µg/g = ppm

* Below Detection Limit of 0.01µg/L

Results: Salem Harbor and Pleasant Prairie



Plant	ACI Rate, lb/MMacf	Mercury in Solid, µg/g	Mercury in Leachate, µg/L	
			TCLP	SGLP
Pleasant Prairie	10	0.5 - 5	BDL	BDL
Pleasant Prairie	10	0.5 - 5	BDL	BDL
Pleasant Prairie	10	0.5 – 5	BDL	N/A
Salem Harbor	0	0.1 – 0.7	0.034	BDL
Salem Harbor	10	0.1 – 0.7	BDL	BDL
Salem Harbor	10	0.1 – 0.7	BDL	BDL

Summary of Hg Release from CUB after ACI
Phase I Field Testing Program

- **Hg in solids increased slightly after ACI**
- **Most leachates below 0.01 µg/L**
- **Max. leachate 0.07 µg/L (Brayton Point)**
- ***Below all EPA water quality/drinking water criterion:***
  - *CCC = 0.77 µg/L*
  - *CMC = 1.4 µg/L*
  - *MCL = 2.0 µg/L*

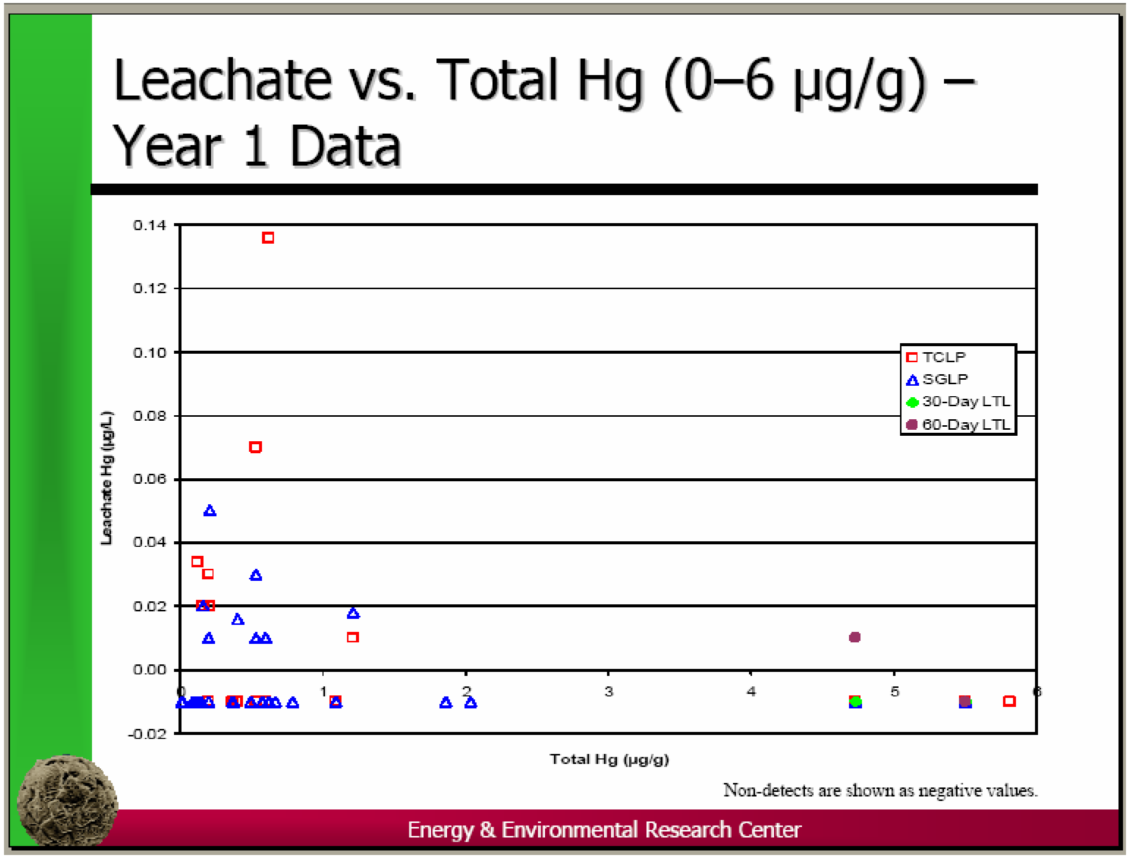
Hg Release from CUB Disposal and Beneficial Use Applications - CONSOL

- **Evaluating CUBs from 14 plants & end products made from CUBs (wallboard, fly ash concrete, etc.)**
  - Wide range of coal types, CUB types, and pollution control configurations
- **Laboratory leaching tests**
  - Screening: All leachates <1.0 µg/L
  - Detailed analysis (6 samples): 0.0075 – 0.084 µg/L
- **Volatilization tests (140^{o}F)**
  - CUBs acted as mercury “sinks”
- **Field leachates from disposal sites still being analyzed**
  - Screening: All leachates <1.0 µg/L

Hg Release Studies - UNDEERC

- **Comprehensive investigation of Hg and other air toxics in CUBs including:**
  - Chemical & physical characterization of CUBs
  - Laboratory methods development & Hg release studies
    - Leaching (TCLP, SGLP, short and long term)
    - Volatilization (short and long term)
    - Microbiologically-mediated release
  - Field investigations

UNDEERC Leaching Test Results



Below all EPA water quality/drinking water criterion:

CCC = 0.77 µg/L
CMC = 1.4 µg/L
MCL = 2.0 µg/L

Source: D. P. Hassett at DOE/NETL's Mercury Control Technology R&D Program Review, July 14-15, 2004

Characterization of Coal Utilization By-Products from Mercury Control Field Testing

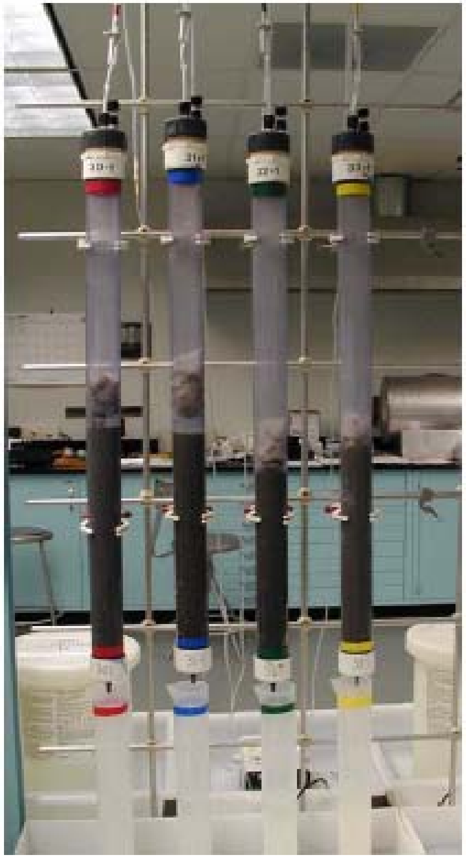
Solicitation DE-RP26-04NT42110

- **Examine Hg in CUBs from NETL-sponsored Hg control projects**
  - 14 projects awarded in 2003-04
- **Use uniform testing procedures and inter-laboratory comparison**
- **Examine leaching, volatilization, and microbial mobilization**
- **Solicitation closed: 08/24/2004**
  - Expect 1 award ~ Spring 2005

NETL In-house Research - Hg Release from CUBs

- **Long-term column leaching tests**
  - 30 to 180 days
  - Leaching liquids
    - Water
    - Acetic acid (TCLP)
    - Synthetic precipitation
    - Sodium carbonate
    - Sulfuric acid

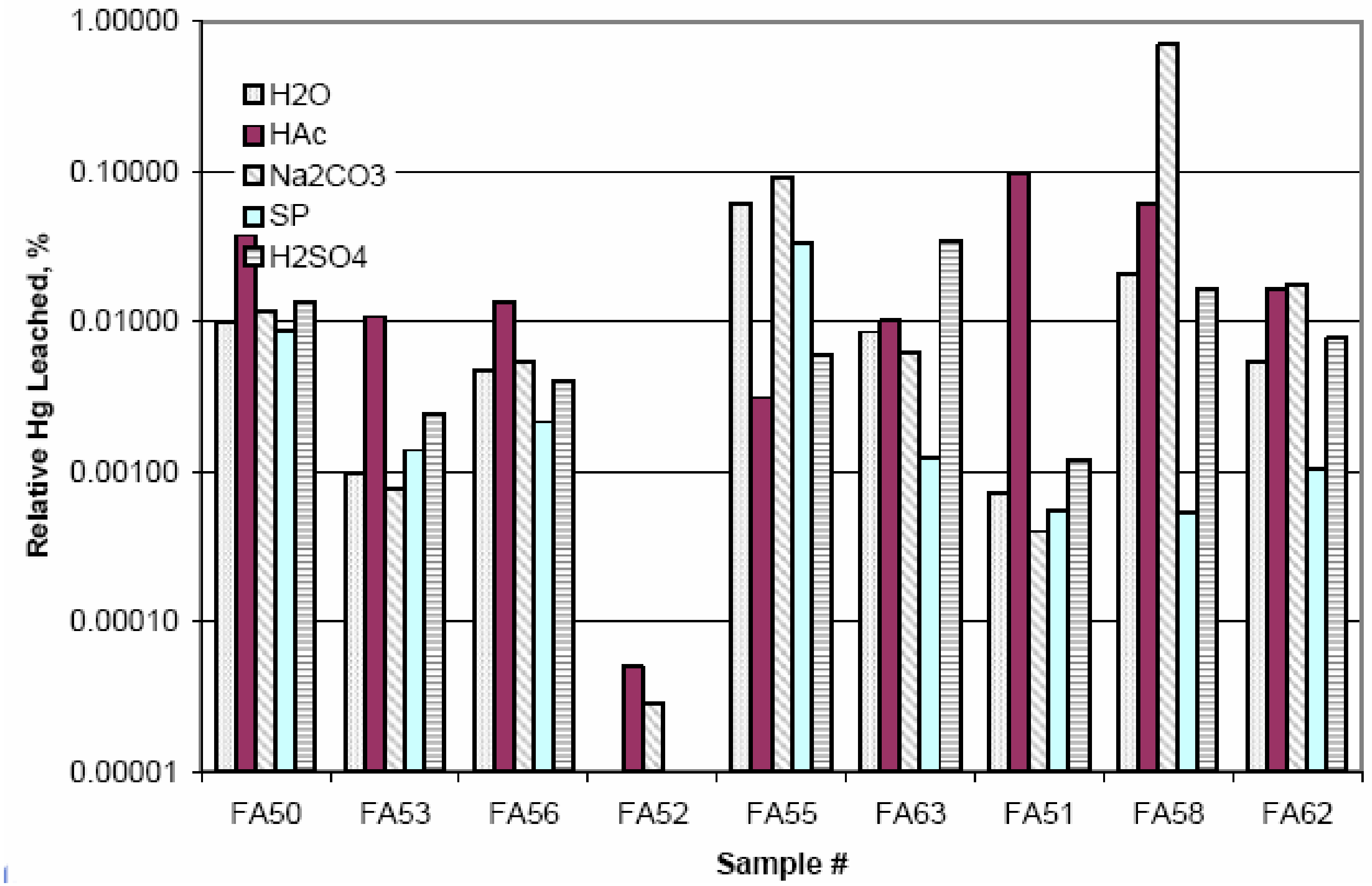
- **Development of rapid leaching protocol**
  - Alternative to TCLP, SGLP; simulates column leaching



Laboratory Leaching Columns

Cumulative Hg Release – In-House Column Leaching Tests

Maximum amount of Hg leached from fly ash less than EPA Hg drinking water standard of 2 ppb



Ref. A. G. Kim at DOE/NETL's Mercury Control Technology R&D Program Review, July 14-15, 2004

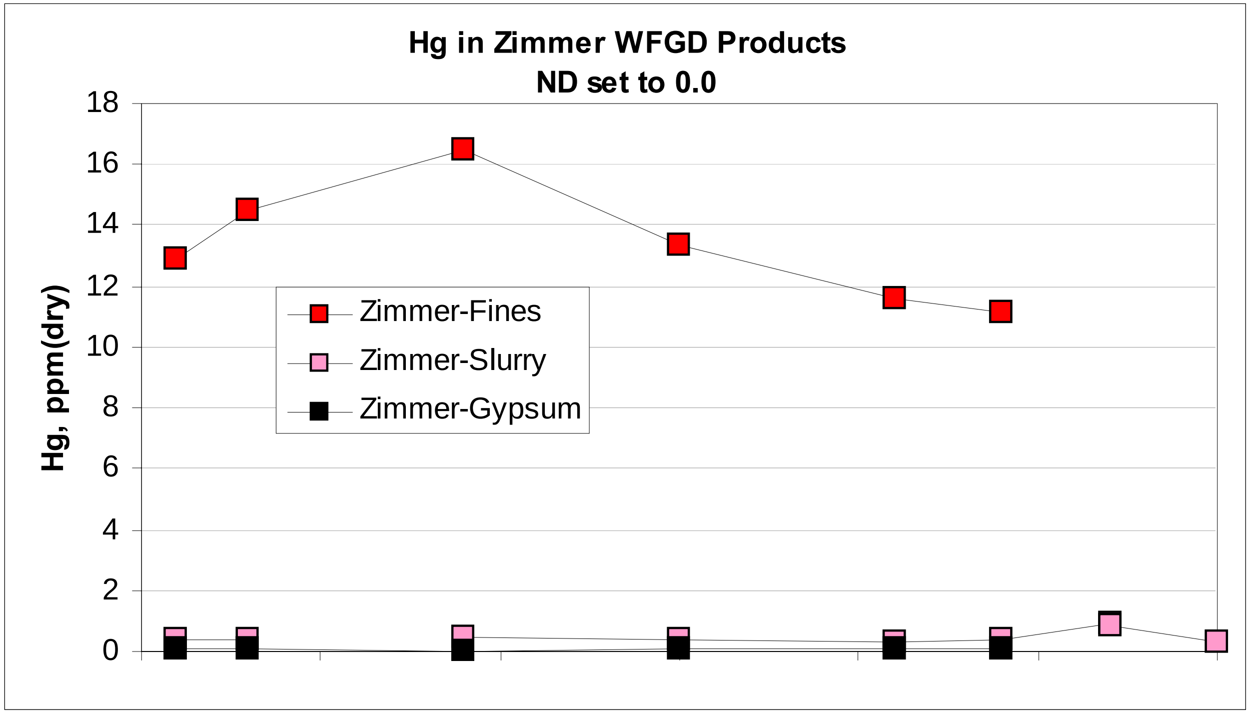
Characterization of Hg in CUBs from Enhanced Oxidation & Wet FGD Removal

Wet FGD Scrubber

- **Endicott Station (MI) and Zimmer Station (OH)**
- **Both used high-S OH bituminous coal and cold-side ESPs**
- **Endicott FGD: Limestone in-situ forced oxidation**
- **Zimmer FGD: Mg-lime external forced oxidation**

NETL

Characterization of Hg in CUBs from Enhanced Oxidation & Wet FGD Removal



"… the mercury compound formed in the wet scrubber is associated with the fines and is not tied to the larger gypsum crystals."

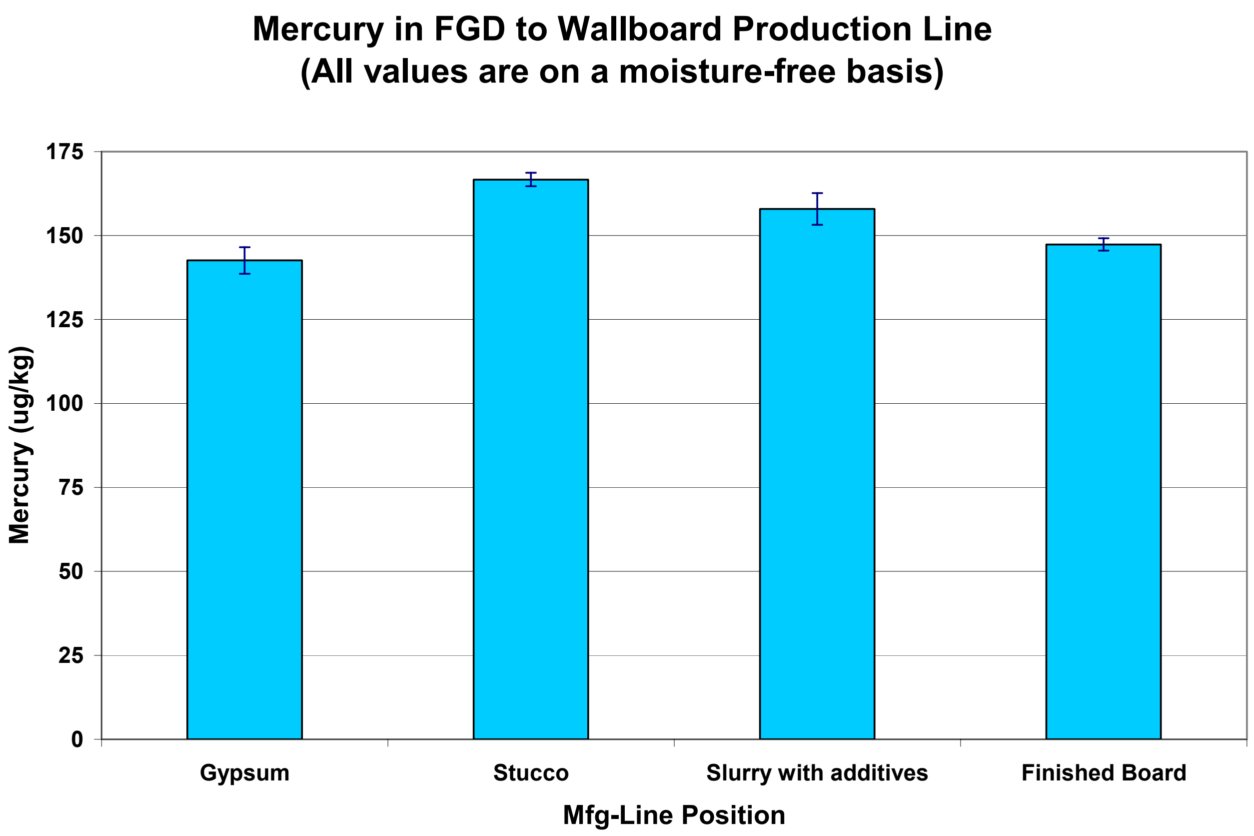
Source: "FULL-SCALE TESTING OF ENHANCED MERCURY CONTROL TECHNOLOGIES FOR WET FGD SYSTEMS" Final Report, DE-FC26-00NT41006, BABCOCK & WILCOX CO. and McDERMOTT TECHNOLOGY, INC. May 7, 2003

NETL In-House
Hg Capture and Release in FGD Solids

- **Samples provided from several power plants and synthetic gypsum wallboard facilities**
  - Samples include:
    - Gypsum, stucco, slurry, and wallboard
- **Determine Hg concentration**
- **Measure leachability**
  - Hg, Al, Cd, Co, Cr, Cu, Fe, Mn, Ni, and Zn

FGD solids

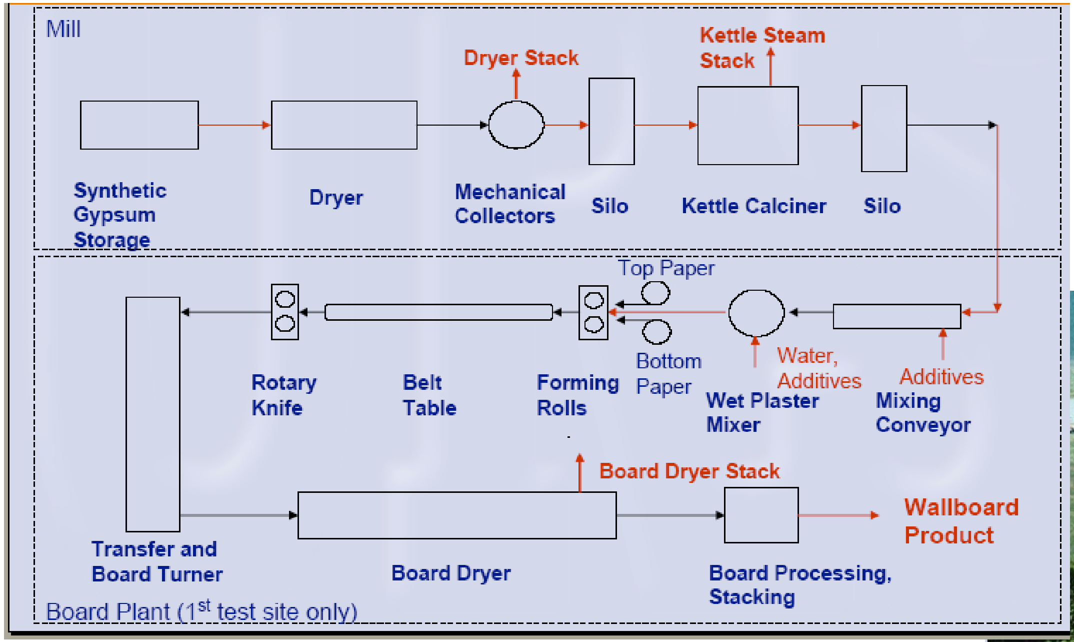
Hg Analysis of Synthetic Gypsum from Power Plant A



Hg concentration in synthetic gypsum samples average about 150 parts per billion.

Fate of Mercury in Synthetic Gypsum Used for Wallboard Production - USG

- **Measure mercury concentrations in solid, liquid, and gaseous streams at 3 operating wallboard manufacturing plants**



Summary of Results to Date

- **Minimal mercury release in typical disposal or utilization applications**
  - Leachate Hg concentrations were significantly lower than EPA drinking water standards (2.0 µg/L) and water quality criteria for protection of aquatic life (0.77 µg/L)

- **Very little (<1% of total) Hg can be extracted from fly ash via leaching**

- **Release of Hg not related to total Hg in CUB**

- **Release of Hg may relate to carbon content**
  - Higher LOI ~ less Hg release

- **Capture via ACI may "retain" Hg better than capture via carbon in fly ash**
  - May relate to number & location of adsorption sites (more research needed)

- **Release of Hg from wallboard manufacture is currently being investigated**

- **DOE/NETL will need to continue to support research on environmental effects of CUBs**

For additional information:

http://www.netl.doe.gov/coal/E&WR/ccb/