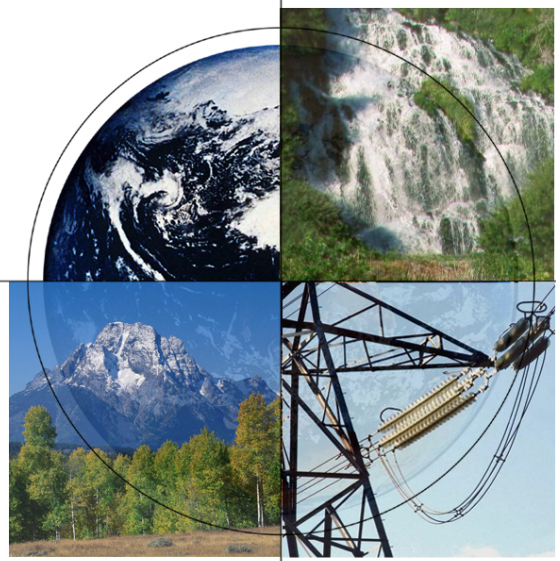
An Update on the U.S. Department of Energy's Phase II Mercury Control Technology Field Testing Program



China Workshop on Mercury Control from Coal Combustion

October 31-November 2, 2005
Beijing, China

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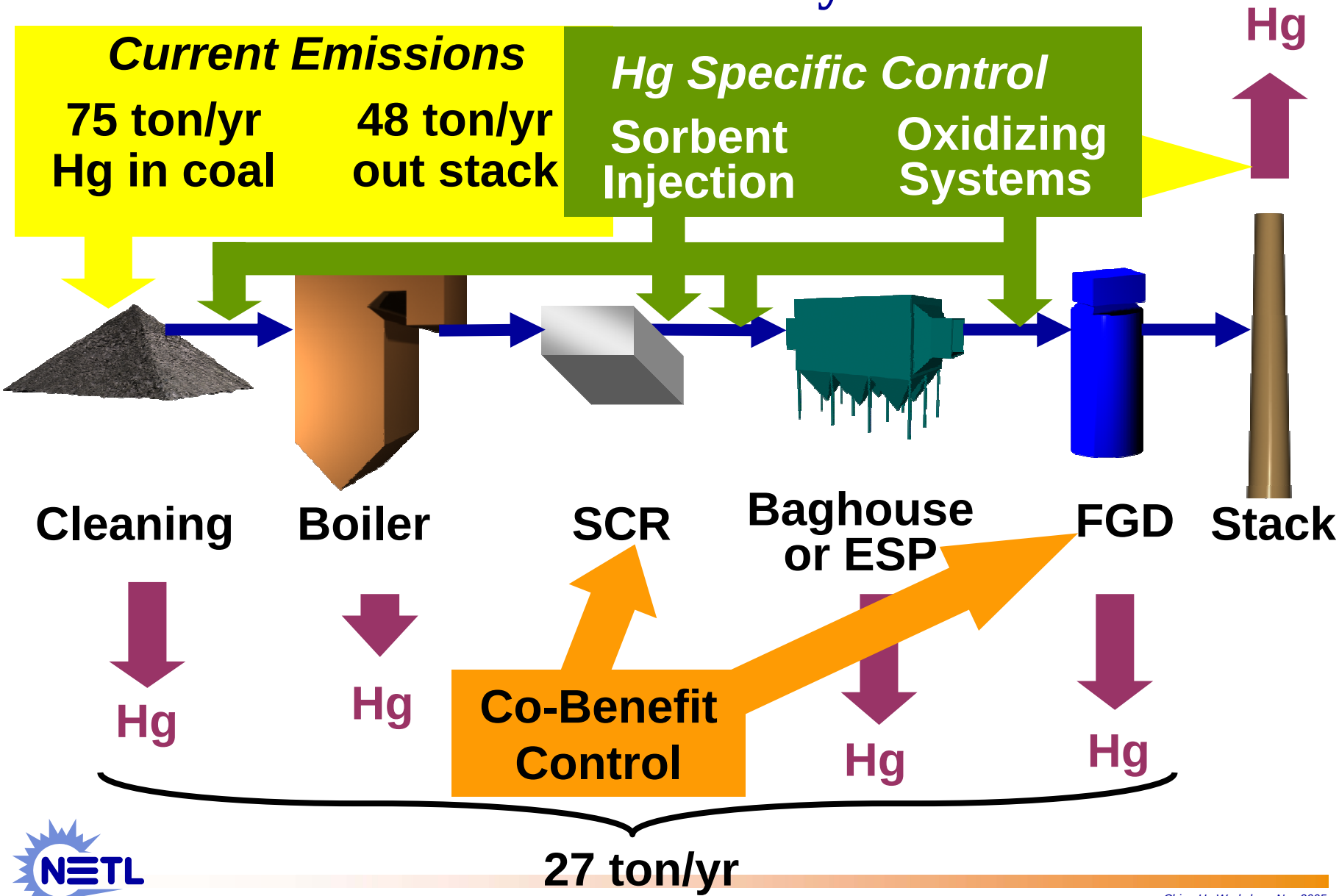
Outline

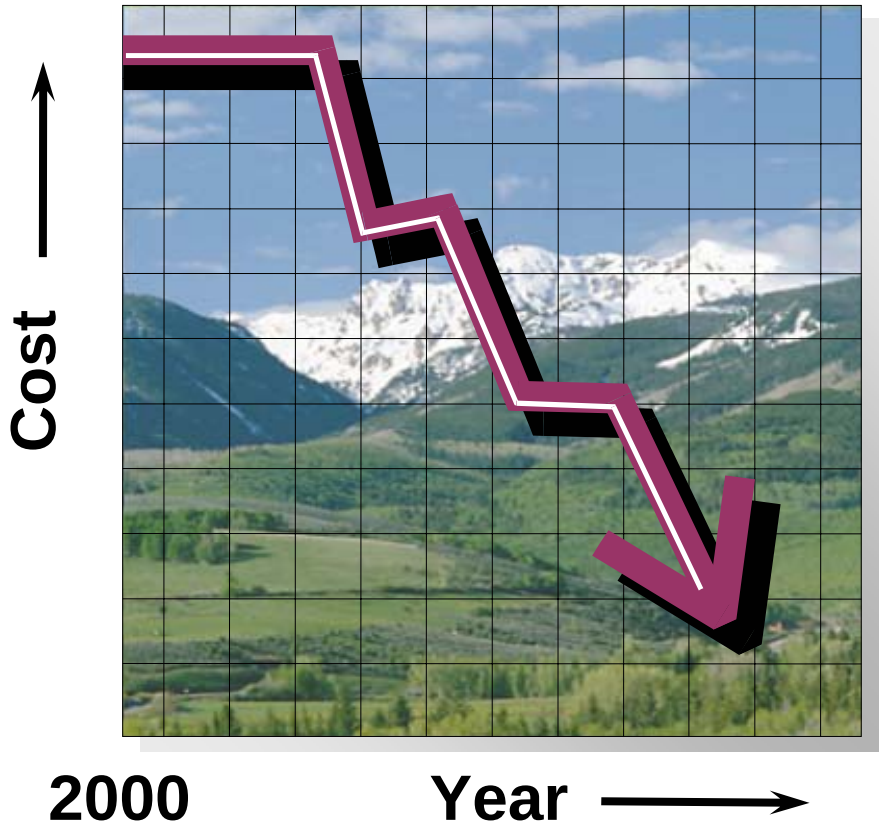
- **Background**
- **Field testing**
  - Mercury-specific technology, focusing on ACI
- **Field testing**
  - Co-benefit control
- **Preliminary ACI costs**
- **Conclusion/future plans**

Power Plant Mercury Control



Mercury Control Technology Program
Performance/Cost Objectives

- Have technologies ready for <u>commercial demonstration</u> by:
  - 2007 that can reduce "uncontrolled" Hg emissions by 50-70%
  - 2010 for all coals that can reduce "uncontrolled" Hg emissions by +90%
- Reduce cost by 25-50% compared to baseline cost estimates



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

Phase II Mercury Control Field Test Projects

- **Fourteen projects (2004-2006)**
- **Long-term (30 days or more @ optimum conditions), large-scale field testing**
- **Broad range of coal-rank and air pollution control device configurations**

Field testing at 28 different coal-fired units --representing approximately 2.3% of 1,165 existing coal-fired generating units.

Phase II Mercury Control Field Test Projects

- **Focus on key technical issues and uncertainties:**
  - Effectiveness of sorbent (carbon) injection and oxidation systems (i.e., catalysts, reagents) particularly with low-rank coals
  - Effectiveness of sorbent injection with small ESP specific collection areas and with hot-side ESP
  - Impact on byproduct use and disposal

DOE/NETL Phase II Mercury Control Field Testing Technology Matrix[a]

Coal Rank	Cold-side ESP (low SCA)	Cold-side ESP (medium or high SCA)	Hot-side ESP	TOXECON	ESP/FGD	SDA/FF or SDA/ESP
Bituminous	Miami Fort 6	Lee 1	Cliffside	Independence	Yates 1	
	Yates 1&2	Lee 3	Buck		Yates 1	
		Portland		Gavin	Conesville	
Subbituminous	Crawford	Meramec	Council Bluffs			Holcomb
		Dave Johnston	Louisa			
		Stanton 1	Will County			Laramie River[b]
Lignite (North Dakota)		Leland Olds 1			Milton Young	Antelope Valley 1
		Leland Olds 1				Stanton 10
						Stanton 10
Lignite (Texas)						
PRB / Bit Blend		St. Clair				
		Monroe				
TX Lignite / PRB Blend				Big Brown	Monticello	
					Monticello	
					Monticello	

Sorbent Injection

Sorbent Injection & Oxidation Additive

Oxidation Additive

Oxidation Catalyst

Chemically-treated sorbent

Other – MERCAP, FGD Additive, Combustion

[a] Matrix based on mercury control technology used during long-term testing.

[b] At Laramie River, parametric tests included: (1) sorbent injection; (2) oxidation additives; (3) sorbent injection with oxidation additives; and (4) chemically-treated sorbent injection.

What is Field Testing?

- Full-scale and slip-stream testing at operating coal-fired power plants
- Longer duration testing (1 – 6 months at optimum conditions)
- Reduced risk compared to bench-scale
- Parametric and optimized testing prior to commercial demonstration

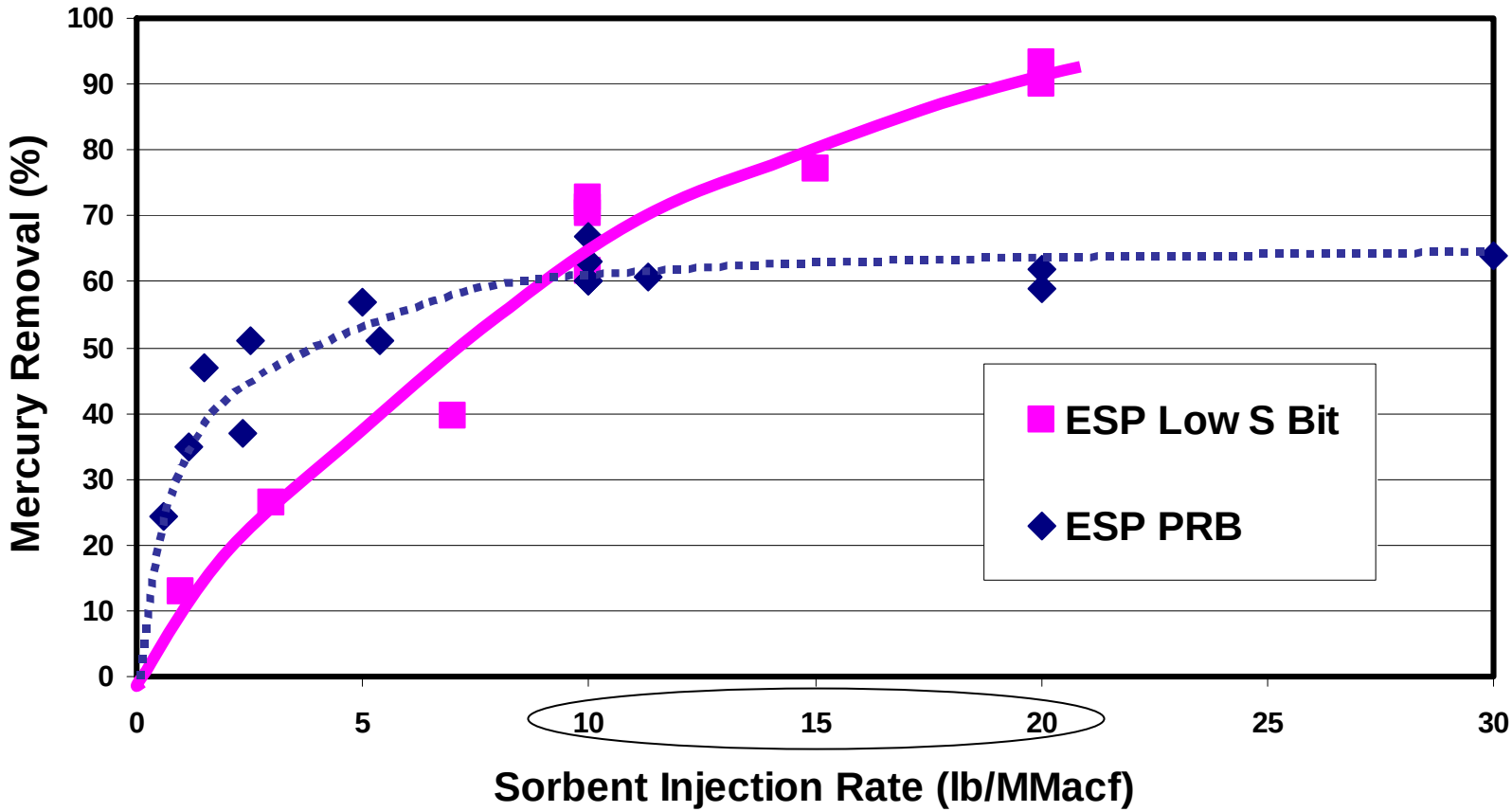
Evaluation of Halogenated AC and Halogen Additives

- **Report on results of field testing of halogenated AC and oxidation additives**
  - Evaluate effectiveness on low-rank coals (Powder River Basin and North Dakota lignite) that produce high levels of elemental mercury
  - Evaluate effectiveness of halogenated AC/oxidation additives on units equipped with ESP and baghouses

Evaluation of Halogenated AC and Halogen Additives – Field Test Sites

- **ADA- ES**
  - Holcomb Station – Powder River Basin (PRB)
  - Meramec Station – PRB
  - Laramie River Station – PRB
- **Sorbent Technologies**
  - St. Clair Station – PRB/Bituminous Blend
- **UNDEERC**
  - Leland Olds -- ND Lignite
  - Stanton Station – ND Lignite

Limited Hg Capture by Conventional ACI on Western Coals

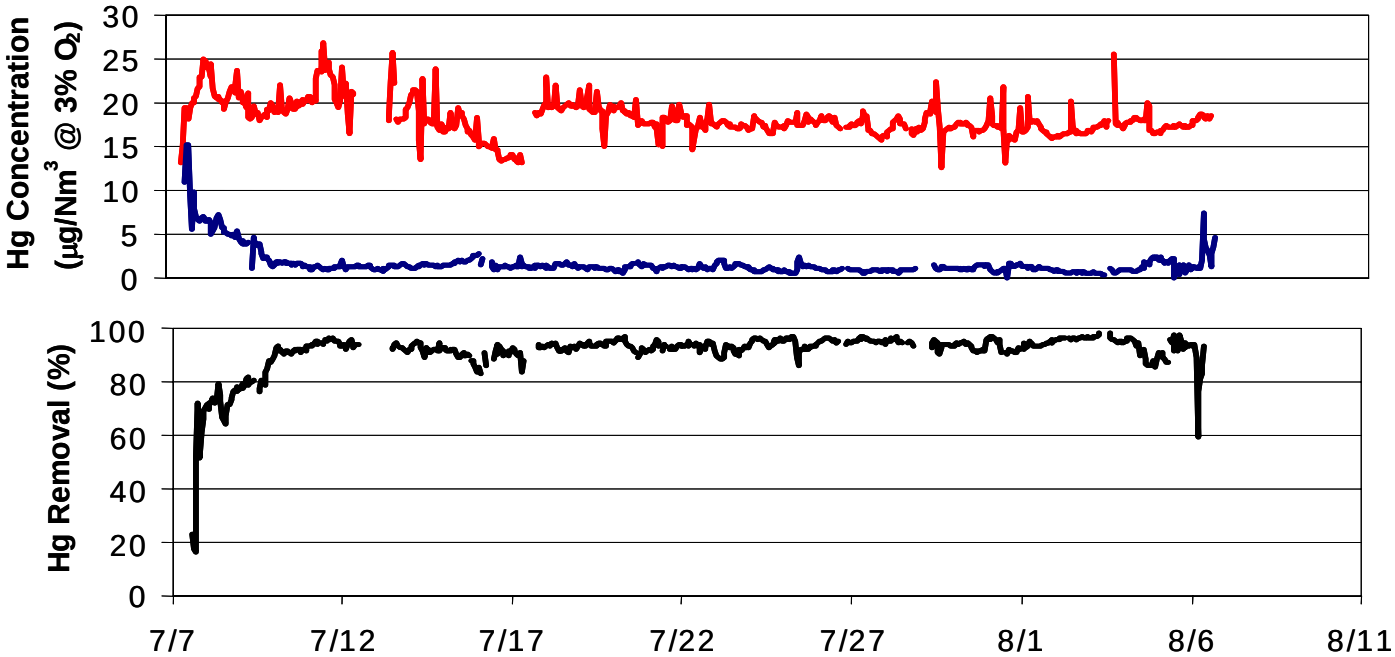


Ref. Mike Durham, ADA-ES, EUCI--"Navigating the Hg Issue," October 19, 2005, Arlington, VA

ADA-ES – Halogenated AC
Preliminary Results

Sunflower Electric's Holcomb Station Unit 1 (PRB, SDA-FF)

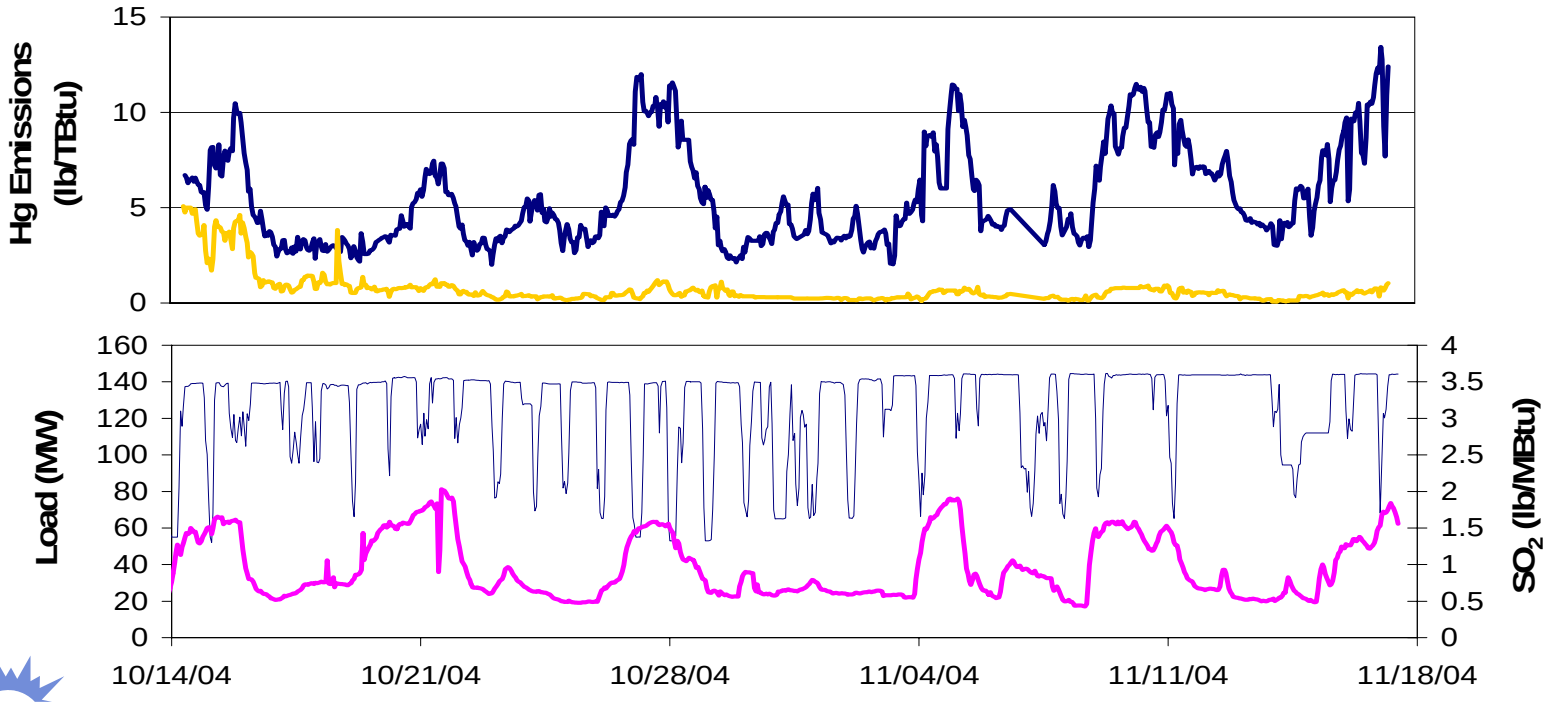
- Baseline mercury removal < 20%
- 30-day long-term test using Norit's DARCO® Hg-LH
- Average mercury removal 93% with 1.2 lb/MMacf (~91% due to sorbent)



ADA-ES-- Halogenated AC
Preliminary Results

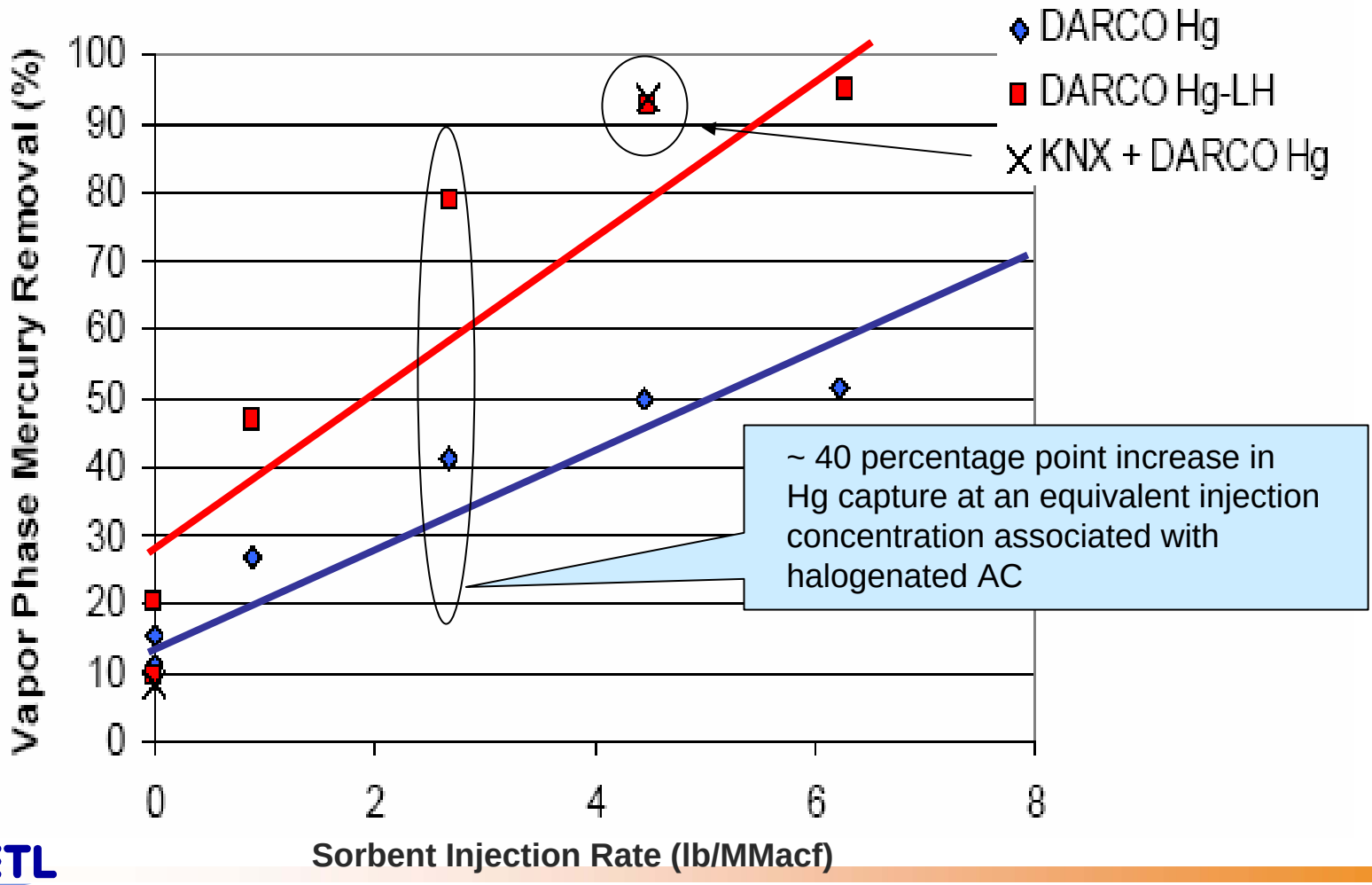
AmerenUE's Meramec Station Unit 2 (PRB, ESP)

- Baseline mercury removal 15-18%
- 30-day long-term test using DARCO® Hg-LH
- Average mercury removal 93% at 3.3 lb/MMacf



ADA-ES – Halogenated AC/Halogen Additives - *Preliminary Results*

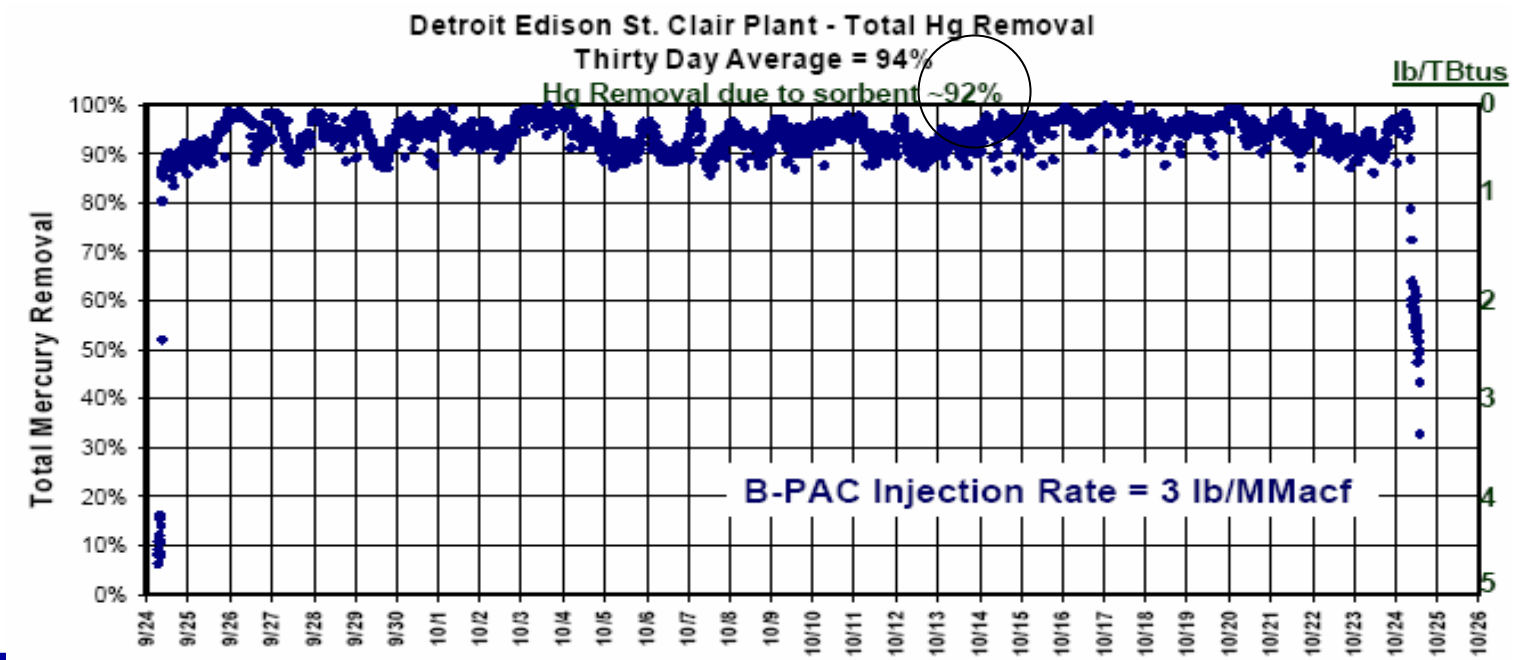
Laramie River Station Unit 3 (PRB, SDA/ESP)



Sorbent Technologies – Halogenated AC (B-PAC) *Preliminary Results*

Detroit Edison's St. Clair Station Unit 1 (PRB-Bit Blend, ESP)

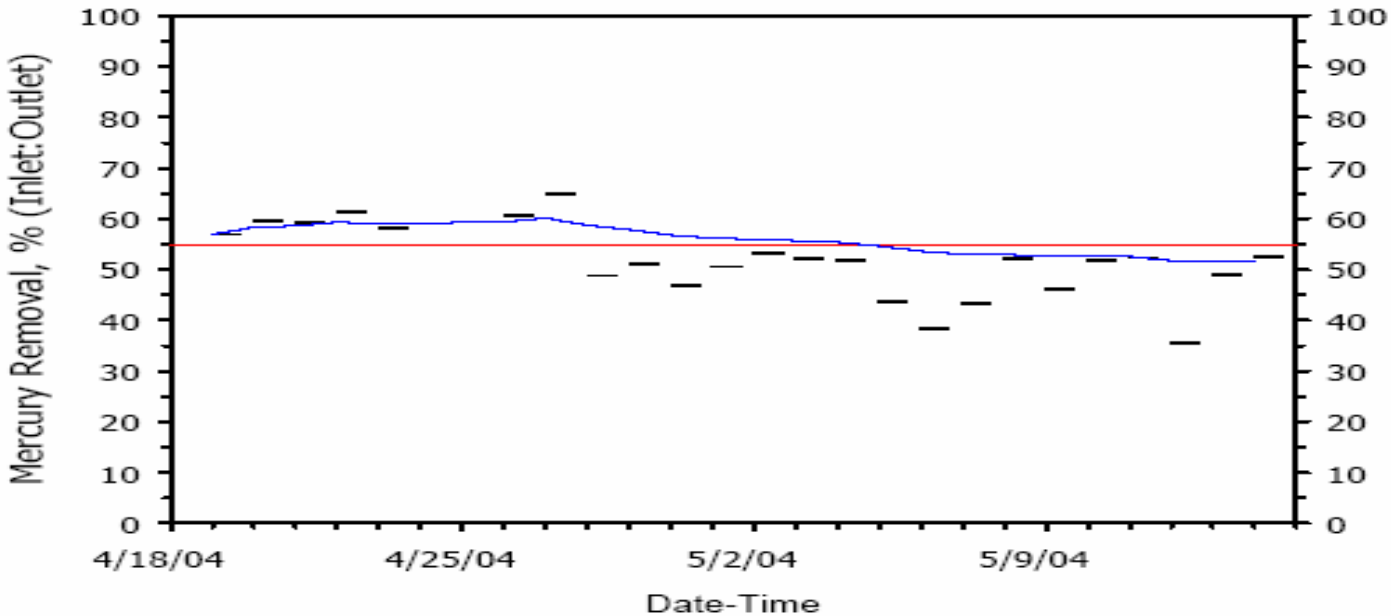
- Baseline mercury removal across ESP varied from 0% to 40%
- One month long-term test with B-PAC™ sorbent injection
- Average mercury removal 94% at 3 lb/MMacf (~92% removal due to sorbent)



UNDEERC-- Halogen Additives
Preliminary Results

Basin Electric's Leland Olds Station Unit 1 (ND Lignite)

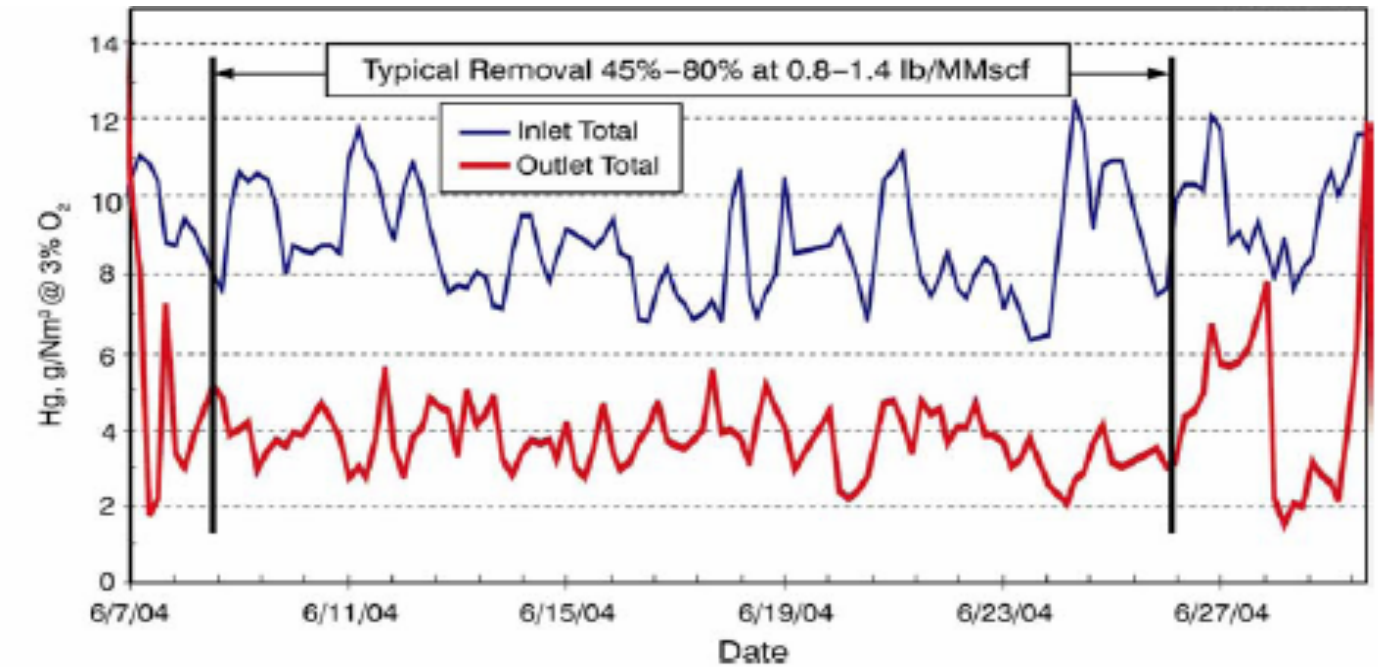
- Baseline mercury removal ~15% across ESP
- 30-day long-term test using DARCO® Hg and $CaCl_2$ coal additive
- Average mercury removal ~63% with coal additive equivalent to 500 ppm chlorine in coal and 3 lb/MMacf sorbent injection



UNDEERC --Halogenated AC
Preliminary Results

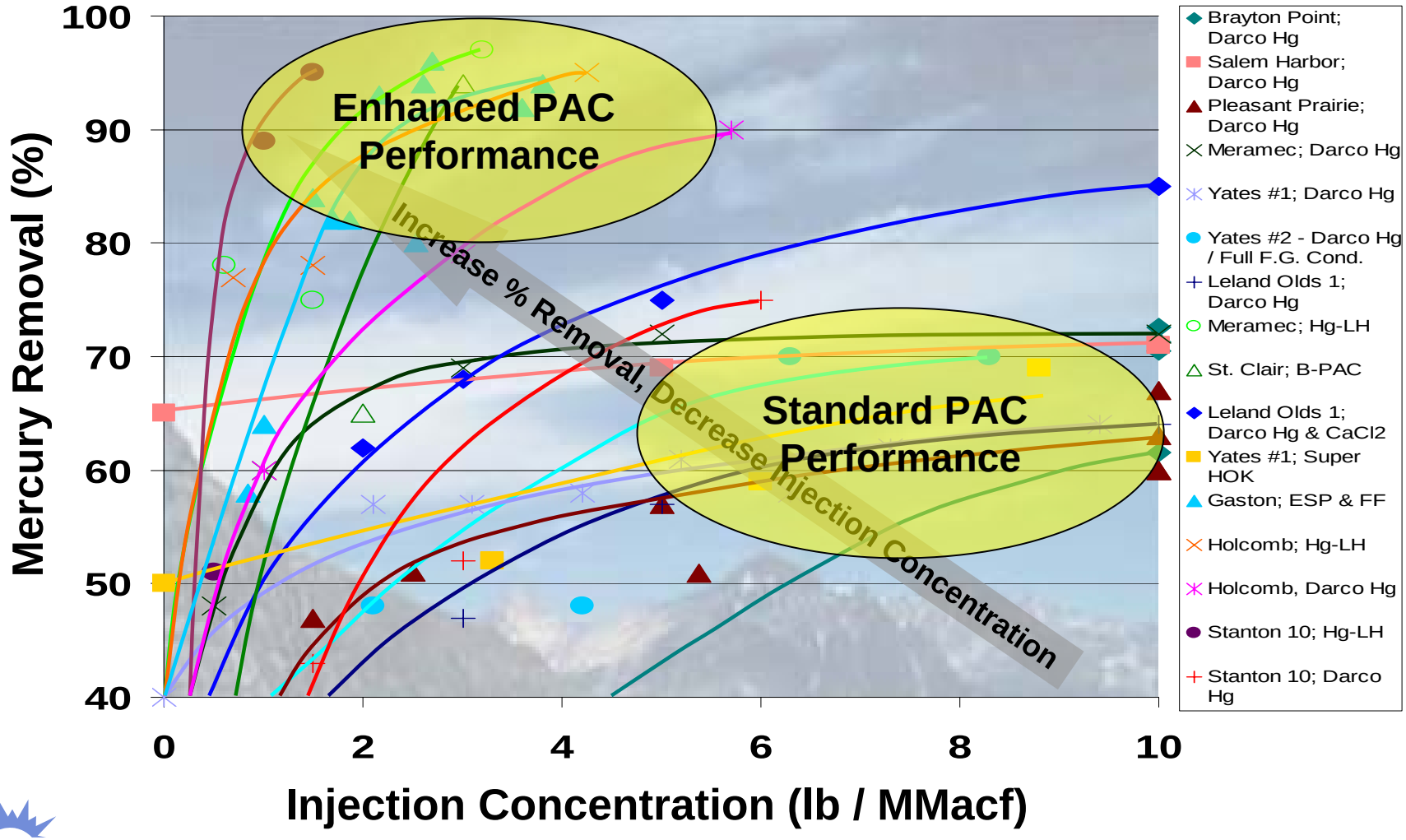
Great River Energy's Stanton Station Unit 10 (ND Lignite)

- Baseline mercury removal <10% across SDA/FF
- 30-day long-term test using DARCO® Hg-LH
- Average mercury removal 60% with 0.7 lb/MMacf

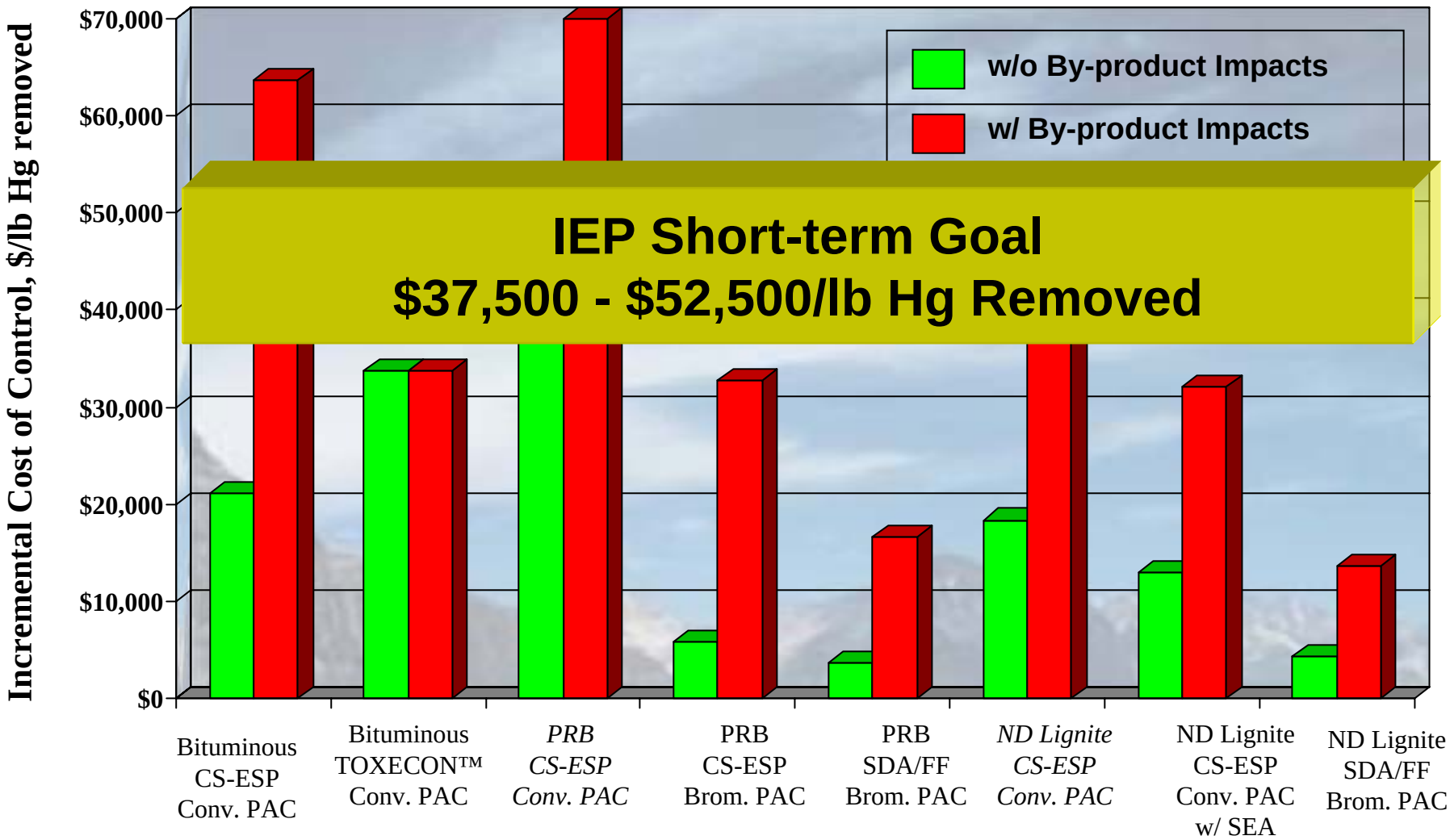


Field Testing Results 2001 – 2005

Comparison of Standard & Enhanced PAC



Incremental Cost of 70% Mercury Control[a]



[a] 60% mercury removal for italicized data labels.

Mercury Emissions from Coal-Fired Facilities with SCR-FGD Systems -- CONSOL

- Evaluate the mercury removal co-benefits achieved by the SCR-FGD combination
- 10 SCR / FGD equipped units:
  - **2 SCR-SDA-baghouse units**
  - **5 SCR-ESP-wet limestone FGD units**
  - **3 SCR-ESP-wet lime FGD units**
- Units fire bituminous coal
- 7 ozone-season and 3 year-round units
- Four units without SCR for comparison

Mercury Emissions from Coal-Fired Facilities with SCR-FGD Systems -- CONSOL

Plant No.	FGD Type	Mercury Flow Rate, mg/sec			Mercury Emissions, lb/10^{12} Btu	% Hg Removal, Coal to Stack	Mercury Balances	
		Coal Feed	AH Outlet	Stack			AH Out vs. Coal Feed	Total Mass Balance
1	Lime Spray Dryer	1.8	2.0	0.22	0.84	87	116%	100%
2	Lime Spray Dryer	1.8	1.6	0.09	0.44	95	90%	99%
5	Limestone, In-Situ Ox.	10.7	12.2	1.52	0.93	86	114%	105%
6	Limestone, Ex-Situ Ox.	6.5	6.8	0.76	1.11	88	104%	96%
7	Limestone, Ex-Situ Ox.	7.0	7.0	1.15	1.77	84	100%	99%
8	Mg-Lime, Ex-Situ Ox.	5.7	6.0	1.61	1.96 (1.11)	72 (84)	104%	110%
9	Mg-Lime, Inhibited Ox.	6.6	7.4	0.88	1.13	87	111%	99%
10	Mg-Lime, Inhibited Ox.	16.9	14.2	1.81	1.01	89	84%	88%

Mercury Emissions from Coal-Fired Facilities with SCR-FGD Systems -- CONSOL

Based on data from tests conducted at 8 sites with SCR/FGD

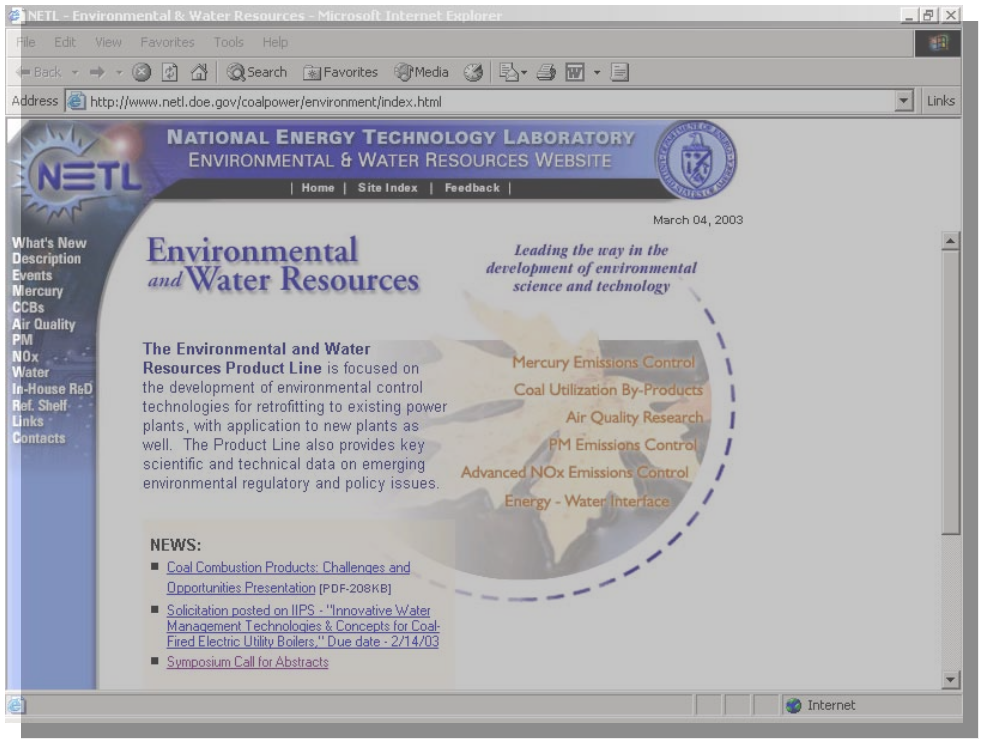
- The SCR/air heater combination effectively oxidized Hg
  - **At all units with SCR, flue gas exiting the air heater contained only 2% to 6% Hg^0**
  - **Same or similar units without SCR, 7% to 34% Hg^0**

- On a coal-feed basis, Hg removals were:
  - **87% and 95% for the lime spray dryer units**
  - **84% to 89% for the lime and limestone wet scrubber units.**
  - **51% to 75% for the wet scrubbed units without SCR**

Key Takeaways from Field Testing

- Halogenated activated carbon and halogen-based additives have been shown to be effective in capturing elemental mercury from low-rank coals with both ESP and baghouses
- Potential coal combustion byproduct impacts remain a “wild card”
- Estimated cost of mercury control on a $/lb removed basis continues to decline
- SCR combined with wet- or dry-scrubbing systems can provide high (~80%-95%) mercury removal with bituminous coals; uncertainty remains with low-rank coals
- Further long-term field testing is needed to bring technologies to commercial-demonstration readiness, particularly related to lignite coal and impacts of SO_3 on ACI effectiveness
- DOE’s RD&D model projects broad commercial availability in 2012-2015

Innovations for Existing Plants Program



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

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