Evaluation of Sorbent Injection for Mercury Control

<u>NETL Meeting</u>

July 12, 2005

DOE/NETL Project Manager: Andrew O'Palko
ADA-ES Project Manager: Sharon Sjostrom
ADA-ES Site Manager: Travis Starns

DOE Cooperative Agreement DE-FC26-03NT41986

Meramec, Monroe, and Conesville Co-funders

AmerenUE*
American Electric Power*
DTE Energy*
Dynegy Generation
MidAmerican
Ontario Power Generation
Southern Company
TVA

ADA-ES
ALSTOM
Arch Coal
EPCOR
EPRI
Babcock & Wilcox
NORIT Americas

**** Host Sites***

Holcomb and Laramie River Co-funders

- Associated Electric Coop
- City of Sikeston
- Empire District Electric Company
- Kansas City Board of Public Utilities
- Kansas City Power and Light
- **Missouri Basin Power Project***
- Nebraska Public Power District
- Pacificorp
- Southern Minnesota Municipal Power Agency
- **Sunflower Electric Power Corporation***
- Tri-State
- TransAlta
- Westar Energy
- Wisconsin Public Service

- ADA-ES, Inc.
- Alstom
- Arch Coal
- EPRI
- Kennecott Coal
- NORIT Americas
- Peabody Coal
- Western Fuels Association

**** Host Sites***

Test Team

- ADA-ES
- EPRI
- Reaction Engineering International
- Other Support
  - stack testing, etc.

Project Goals

Reduce the uncontrolled mercury emissions by 50 to 70% at a cost 25 to 50% lower than DOE basis ($60,000/lb Hg removed)

- Evaluate performance of sorbent injection for mercury control
- Determine process/equipment costs for various levels of mercury removal
- Quantify balance-of-plant impacts

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Five Sites Included in Program

Test Site	Coal	Pollution Control
DTE Energy Monroe	**PRB/Bit Blend**	SCR Cold Side ESP
Sunflower Electric Holcomb	**PRB** *PRB/Bit Blend*	SDA + FF
Ameren UE Meramec	**PRB**	Cold Side ESP
Missouri Basin PP Laramie River	**PRB** *PRB/Bit Blend*	SDA + ESP
AEP Conesville	**Bituminous**	Cold Side ESP WFGD

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Sunflower Electric Holcomb Station

Unit Capacity
- 360 MW

Test Portion
- 180 and 360 MW

Coal
- PRB
- Hg Content:
  - 0.04 – 0.1 ppm-dry
- Cl Content:
  - 7-35 ppm-dry

SO_2 Control – SDA

Particulate Control – FF

Testing Completed August 2004

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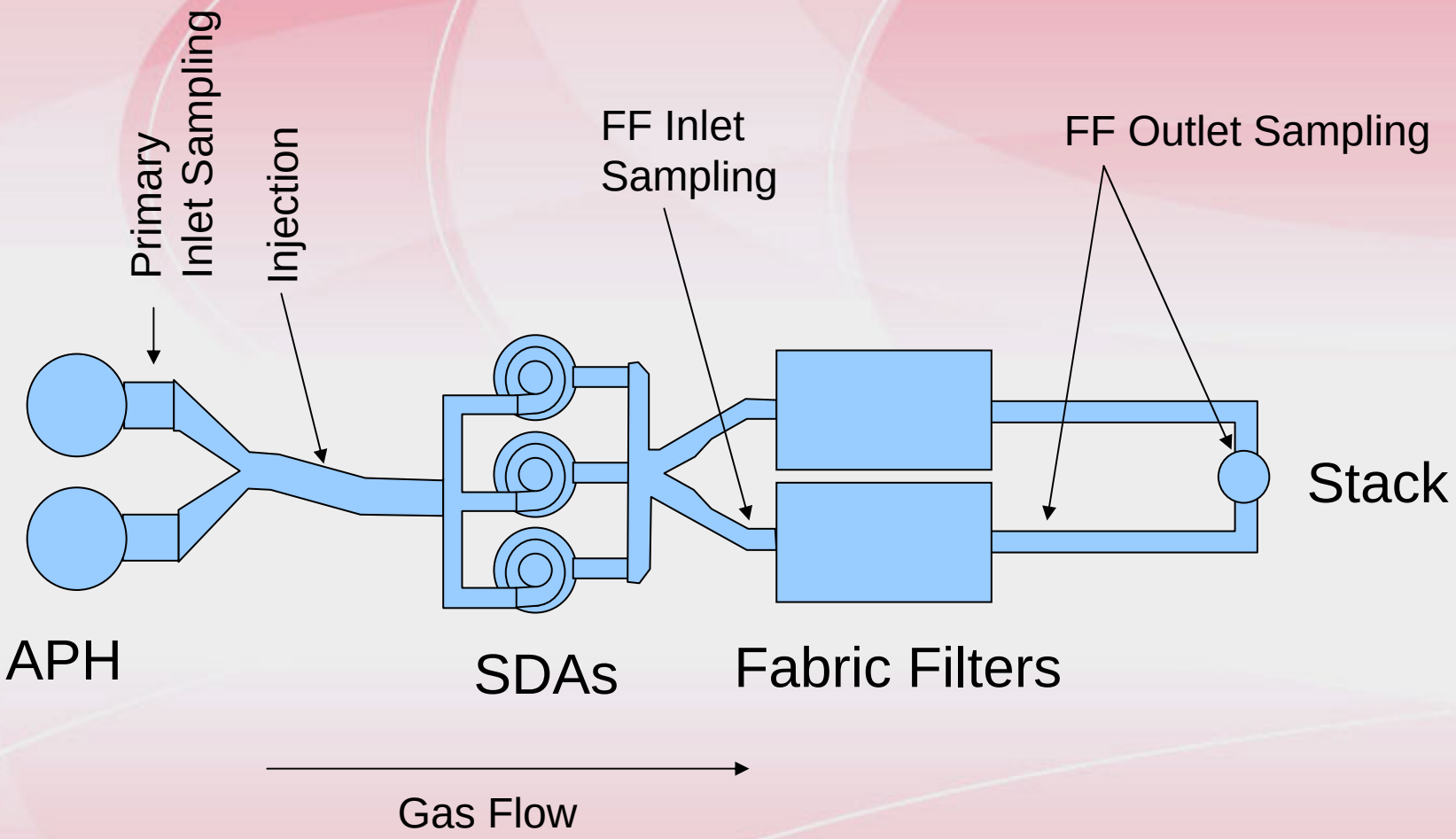
Holcomb Overall Layout

360 MW



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AmerenUE Meramec Plant Unit 2

Unit Capacity
- 140 MW

Test Portion
- 70 MW

Coal
- PRB
- Mercury Content:
  - 0.04 – 0.1 ppm-dry
- Chlorine Content:
  - 7-35 ppm-dry

NOx Control – SOFA, LNB

SO_2 Control – Compliance Coal

Particulate Control – CSESP

SCA = 320 ft^2/acfm

Testing Completed October 2004

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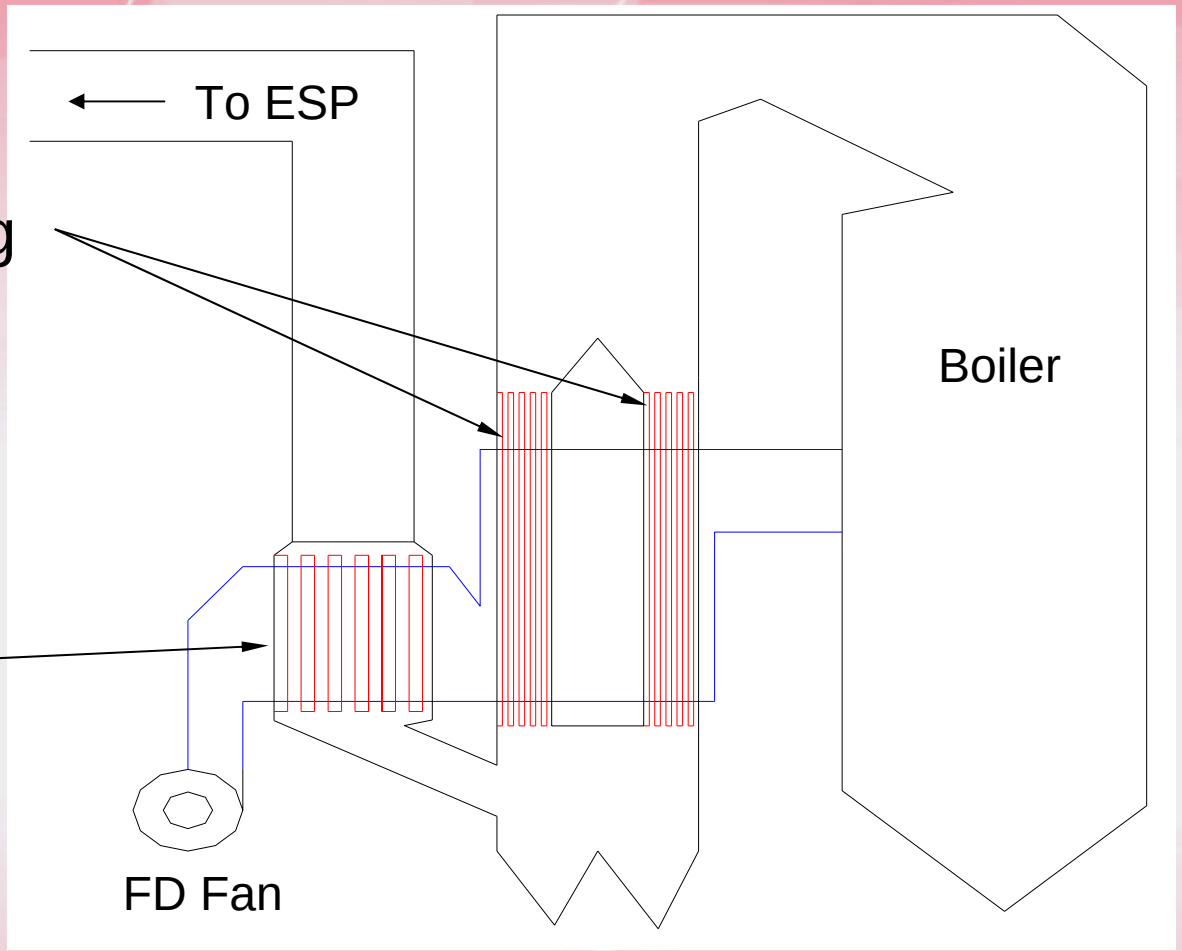
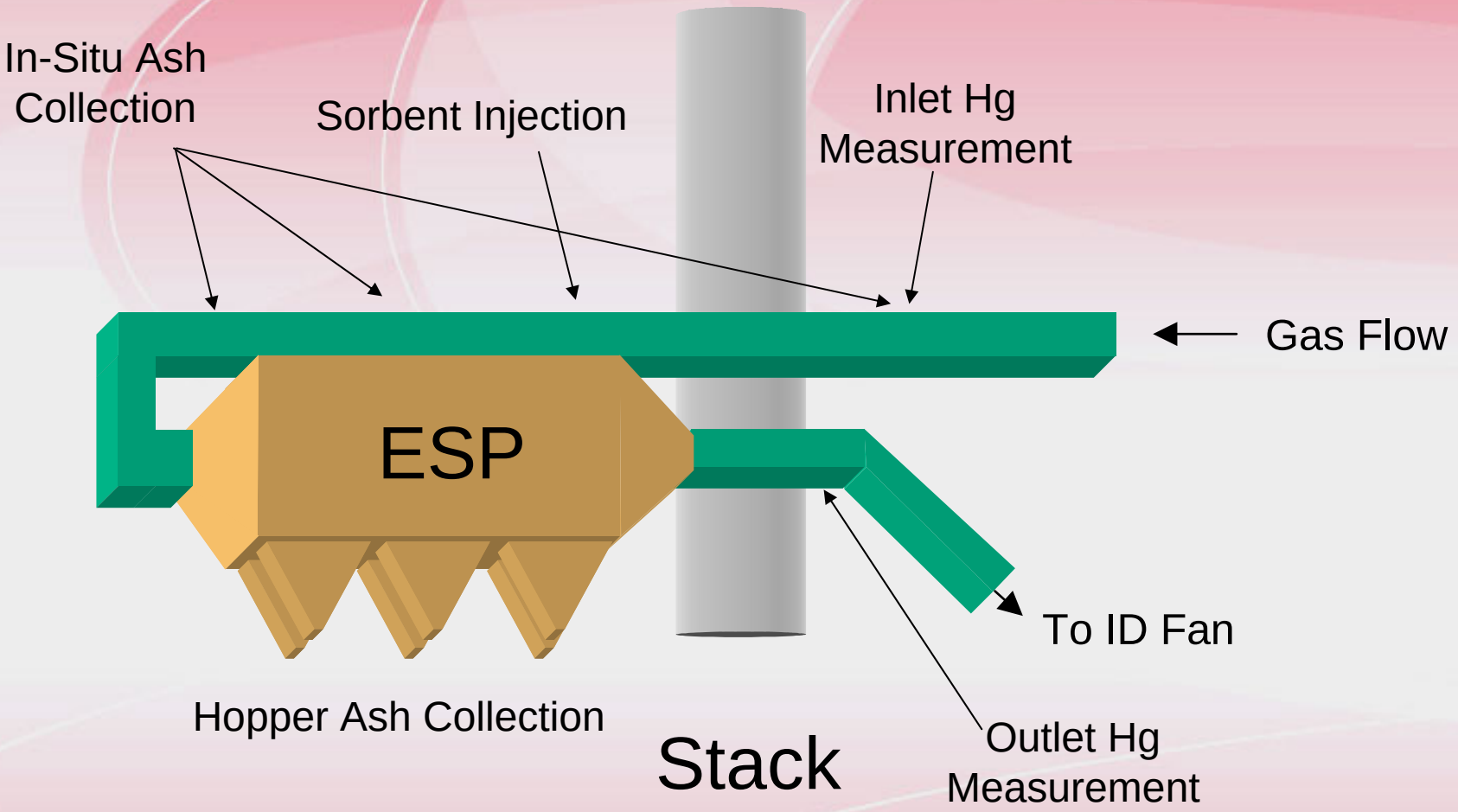
Air Heater Configuration - Tubular



Total Residence Time ~ 5.5 seconds at full load

Meramec Overall Layout



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Missouri Basin Power Project
Laramie River Station Unit 3

Unit Capacity
- 550 MW

Test Portion
- 140 MW

Coal
- PRB
- Mercury Content:
  - 0.04 – 0.1 ppm-dry
- Chlorine Content:
  - 7-35 ppm-dry

SO_2 Control – SDA

Particulate Control – CSESP

SCA = 599 ft^2/acfm

Testing Completed March 2005

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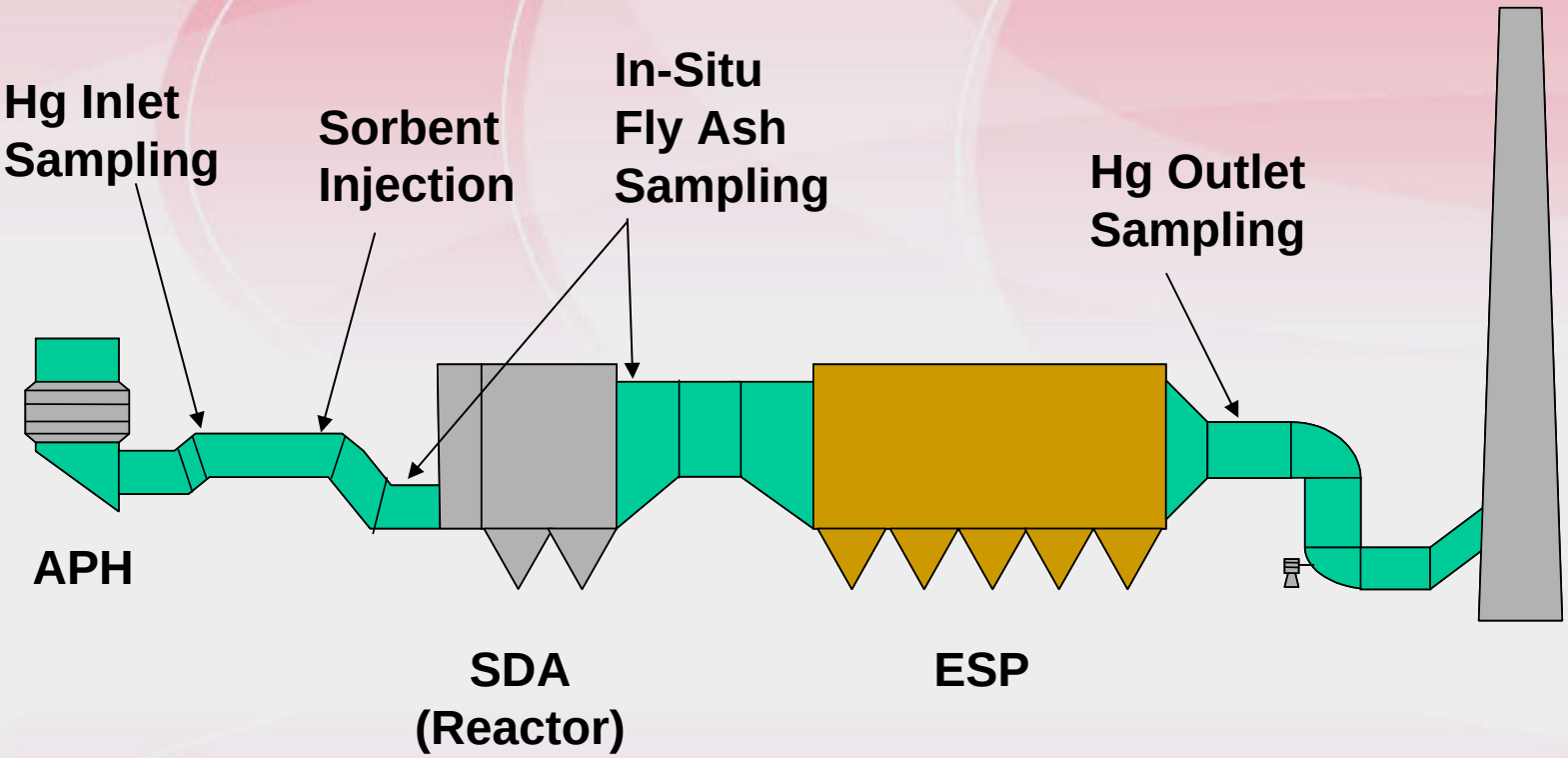
Laramie River Overall Layout



DTE Energy Monroe Station Unit 4

Unit Capacity
- 785 MW

Test Portion
- 196 MW

Coal
- Blend: PRB/bituminous (60/40 typ)
- Mercury Content:
  - 0.04 – 0.15 ppm-dry
- Chlorine Content:
  - PRB: <50 ppm-dry
  - Bit.: 800 – 2000 ppm - dry

SO_2 Control – Fuel Blending

Particulate Control – CSESP

SCA = 258 ft^2/acfm

Testing Completed July 2005

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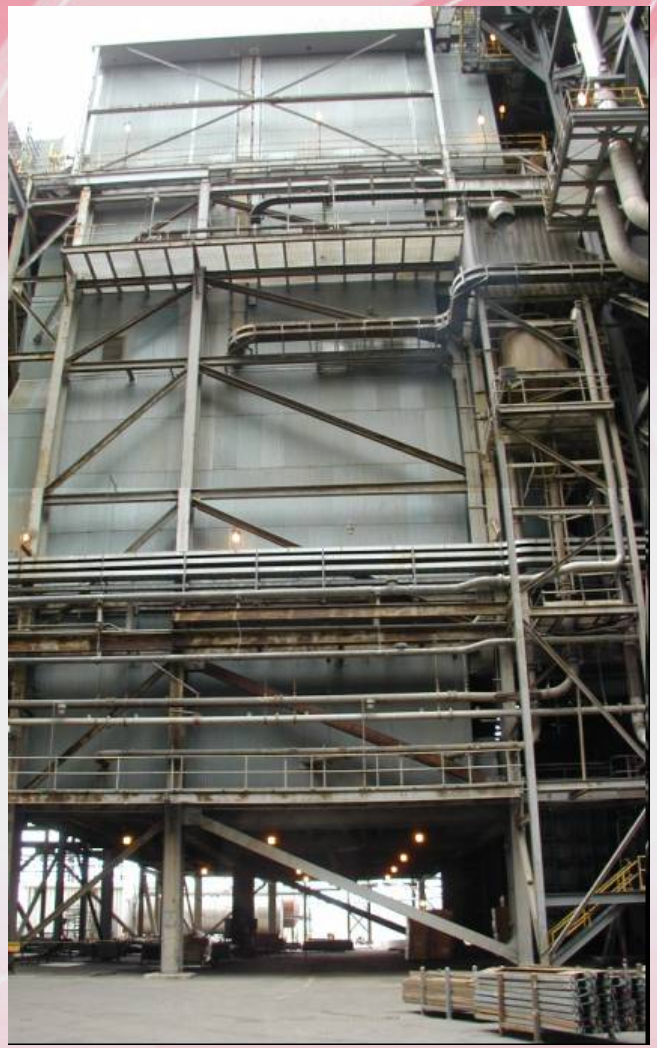
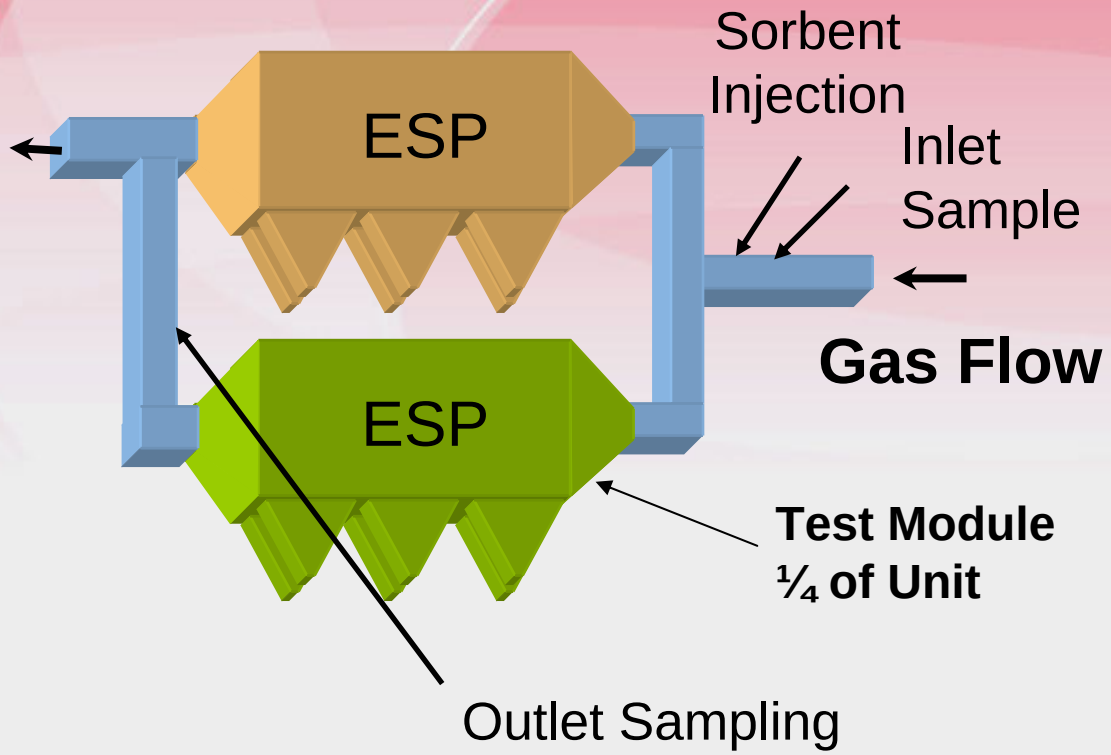
ESP General Arrangement





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AEP Conesville Unit 6

Unit Capacity
- 400 MW

Test Portion
- 400 MW

Coal: Bituminous
- Mercury Content:
  - 0.1 – 0.5 ppm-dry
- Chlorine Content:
  - 200 - 2500 ppm – dry
- Sulfur Content:
  - 2 – 4.5 %

SO_2 Control – Wet FGD

Particulate Control – CSESP

SCA = 300 ft^2/acfm

Testing Planned March – May 2006

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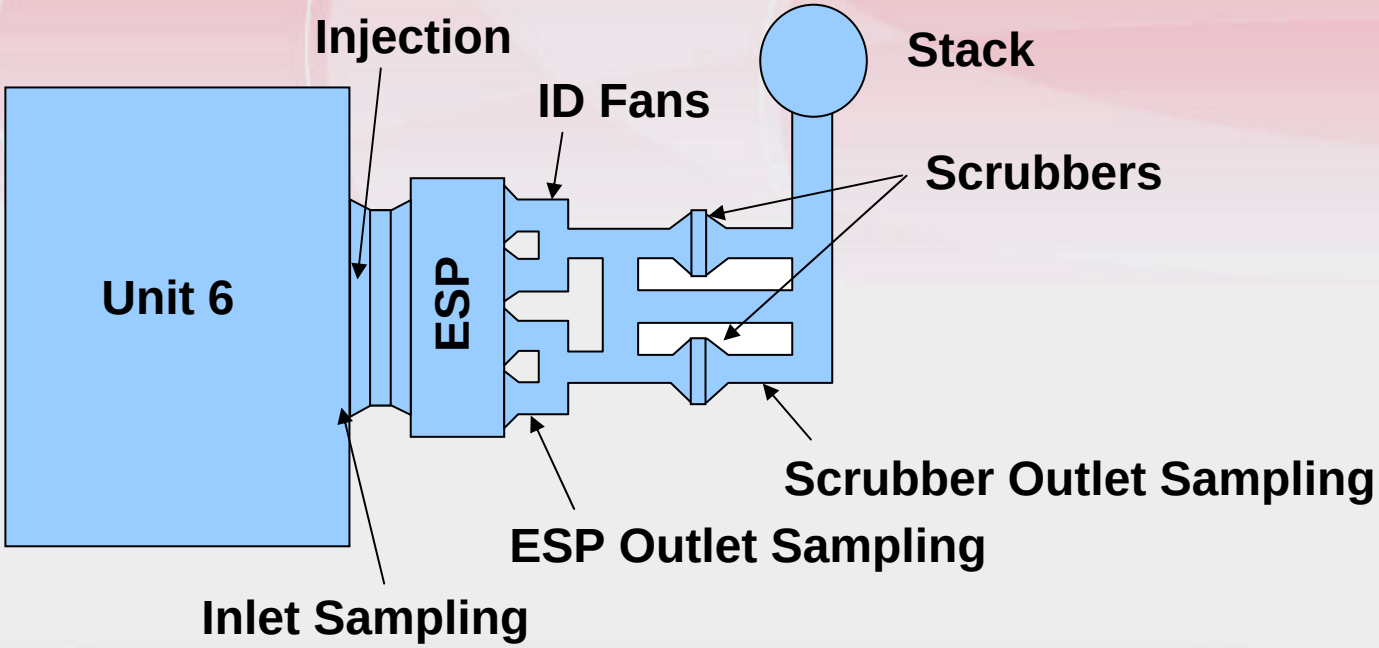
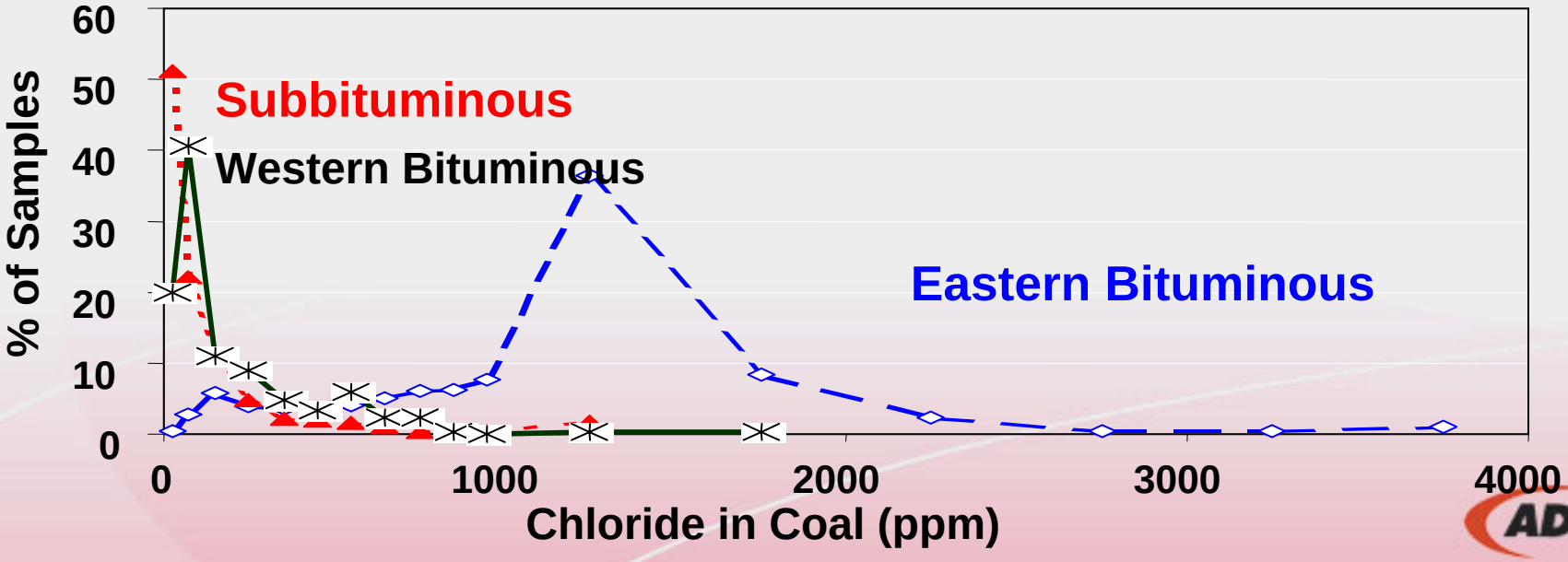
Conesville Overall Layout



Hg Removal with Existing Equipment

ICR Data

Controls	Bituminous	Subbituminous (PRB)
CSESP	46%	16%
FF	83%	72%
SDA + FF	98%	25%



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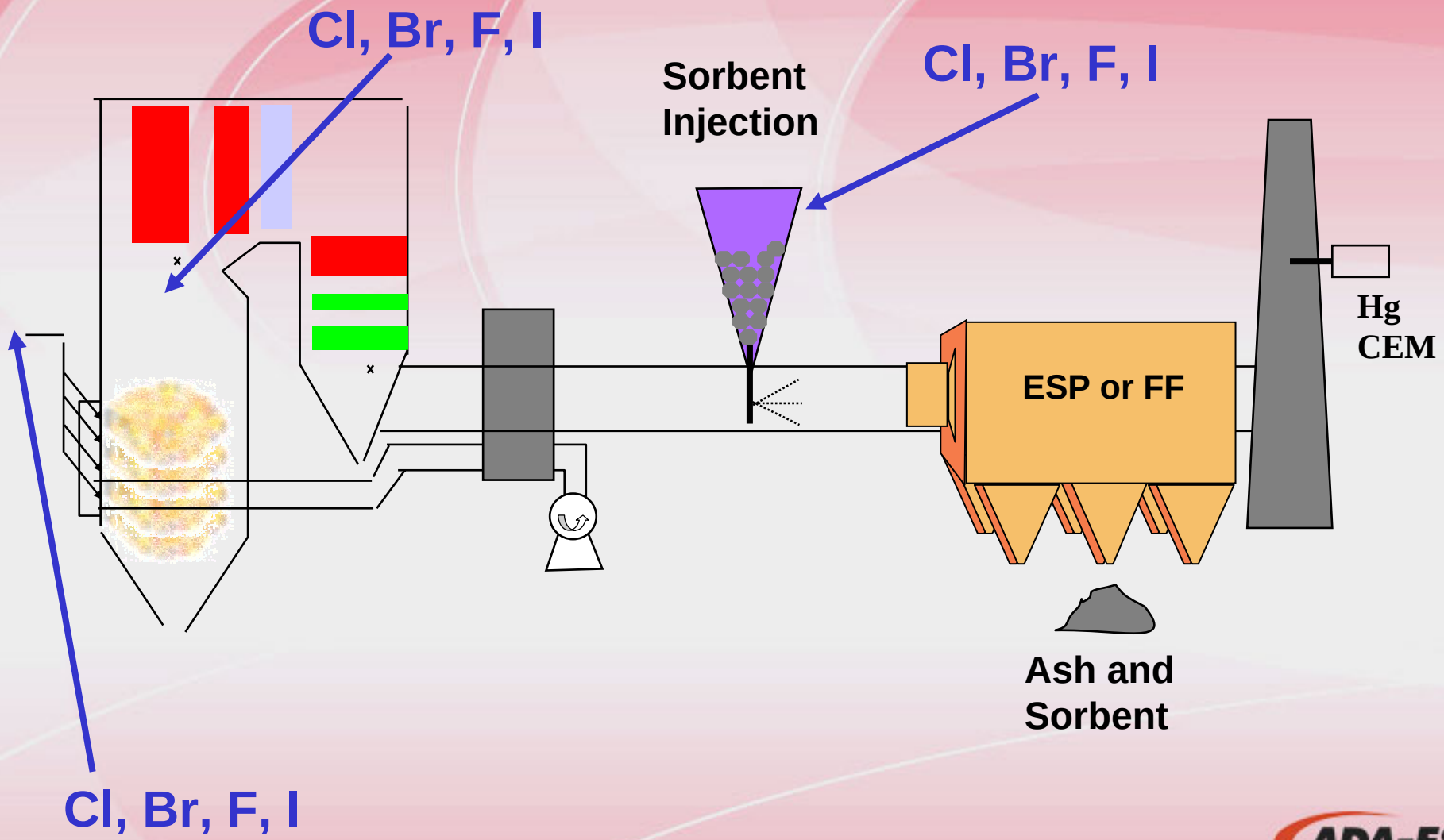
Enhancing Mercury Removal for Western Coals



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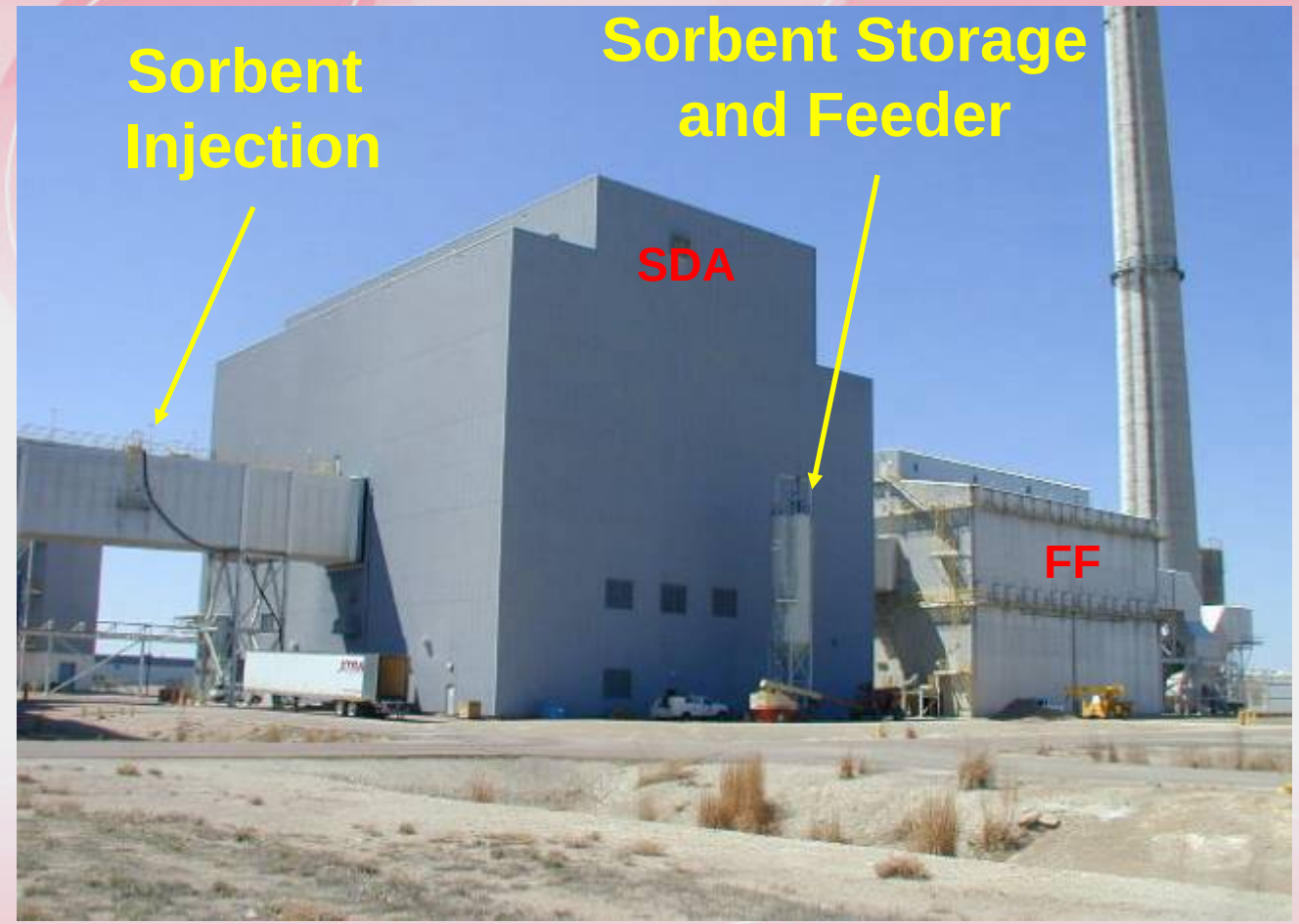
ACI System at Holcomb



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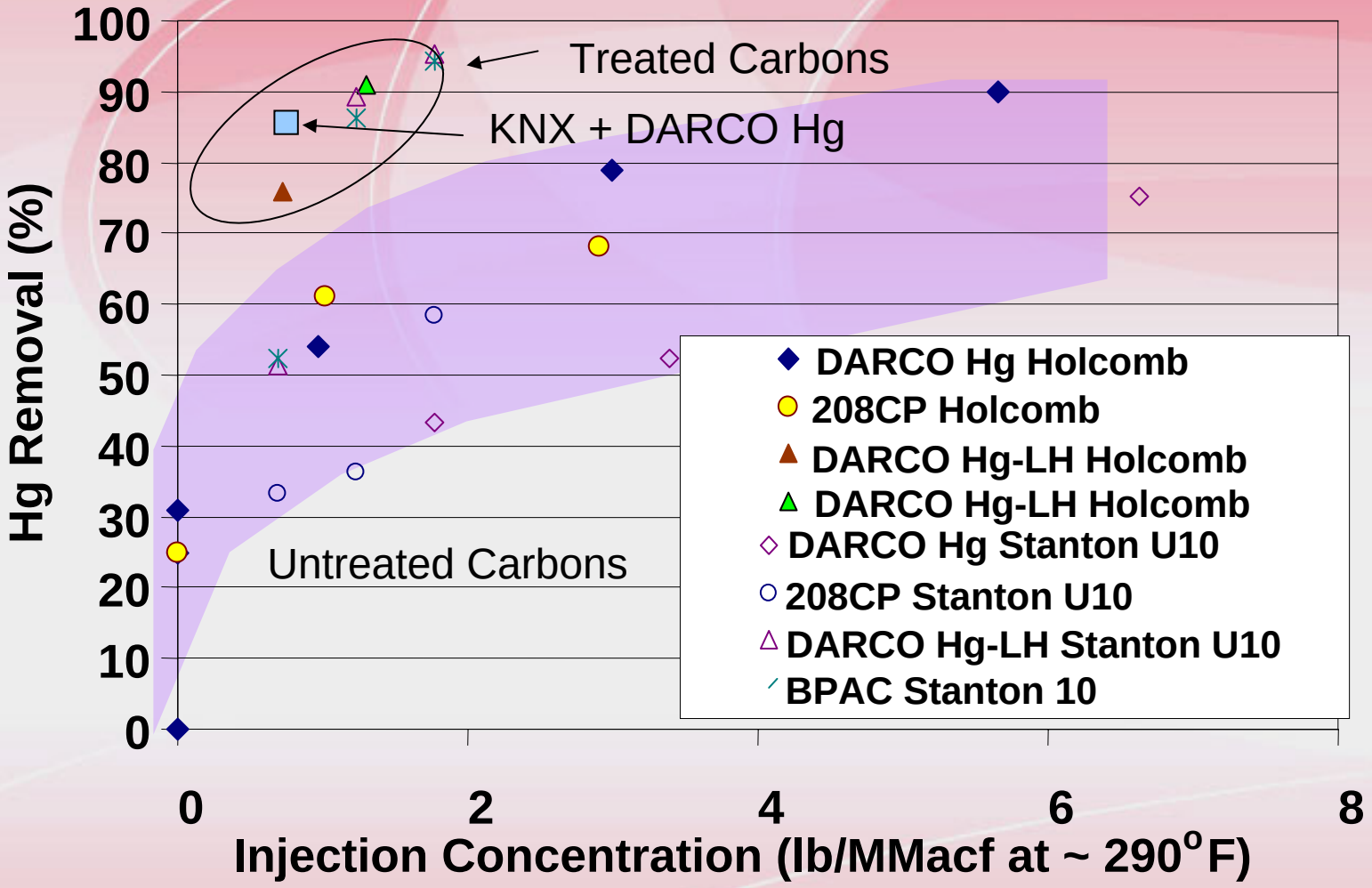
SDA Results, PRB and Lignite Fuels



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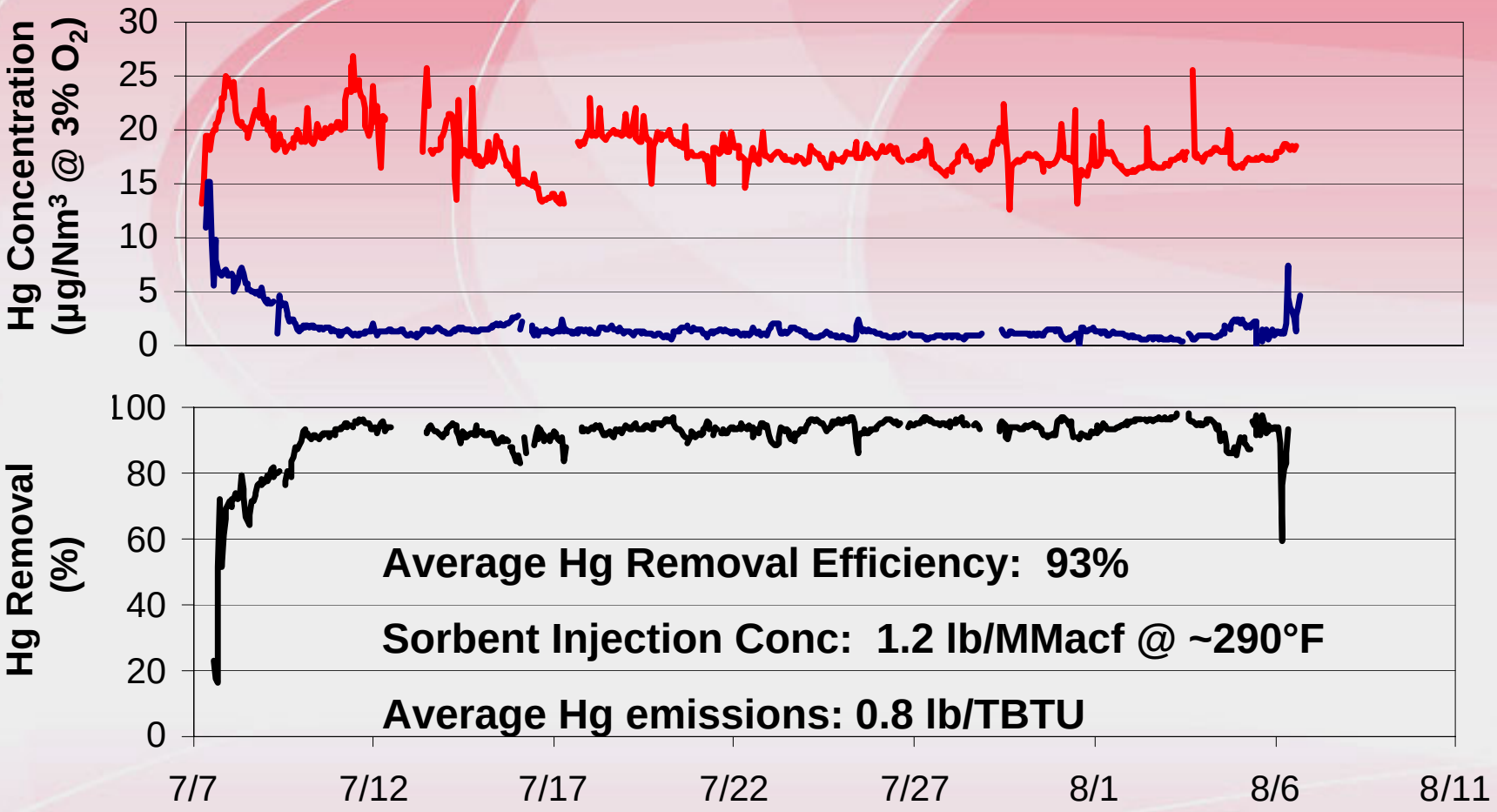
Holcomb: 30-day Long Term Results DARCO Hg-LH Injection



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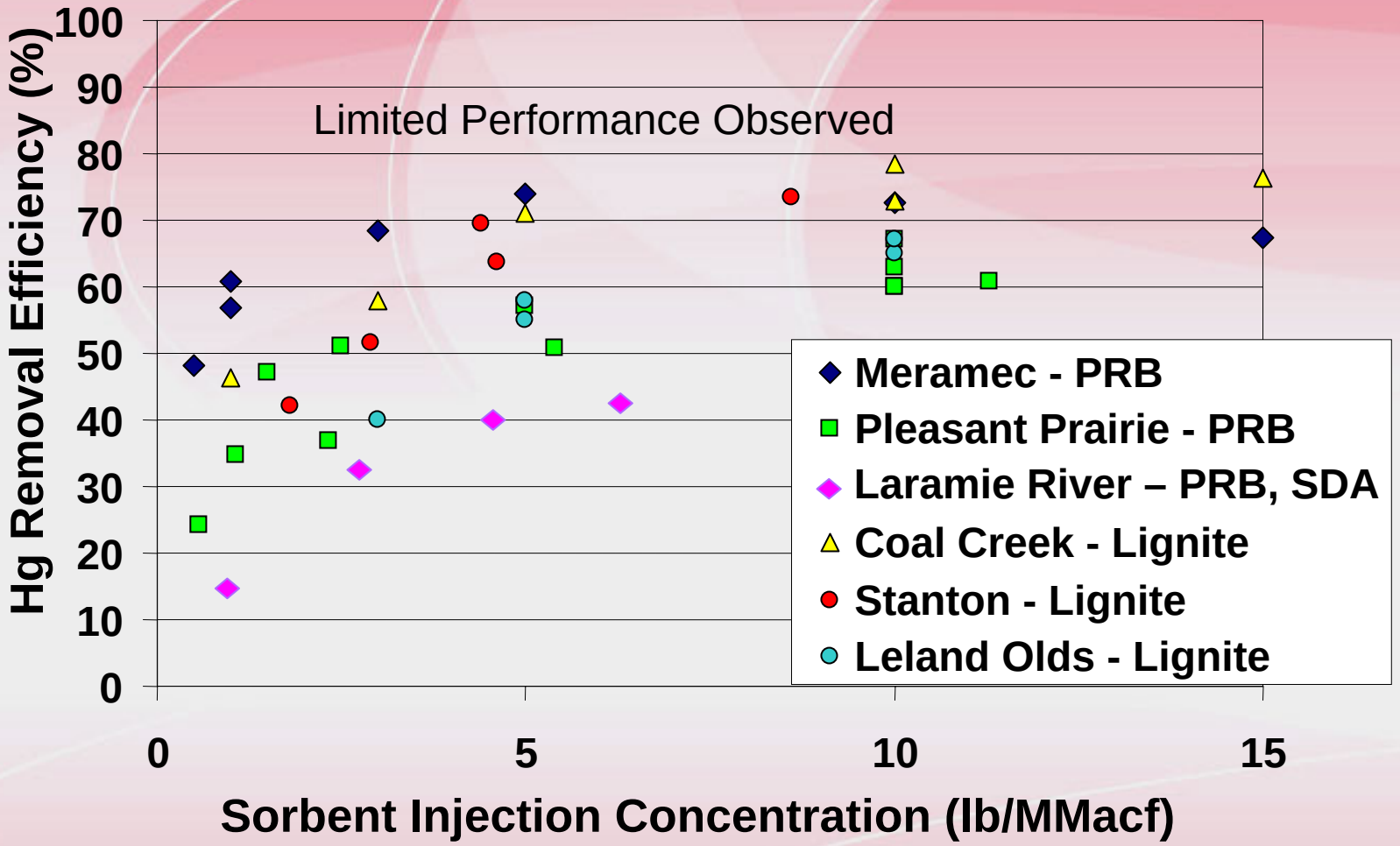
Untreated PAC Injection into ESP PRB and Lignite Coals



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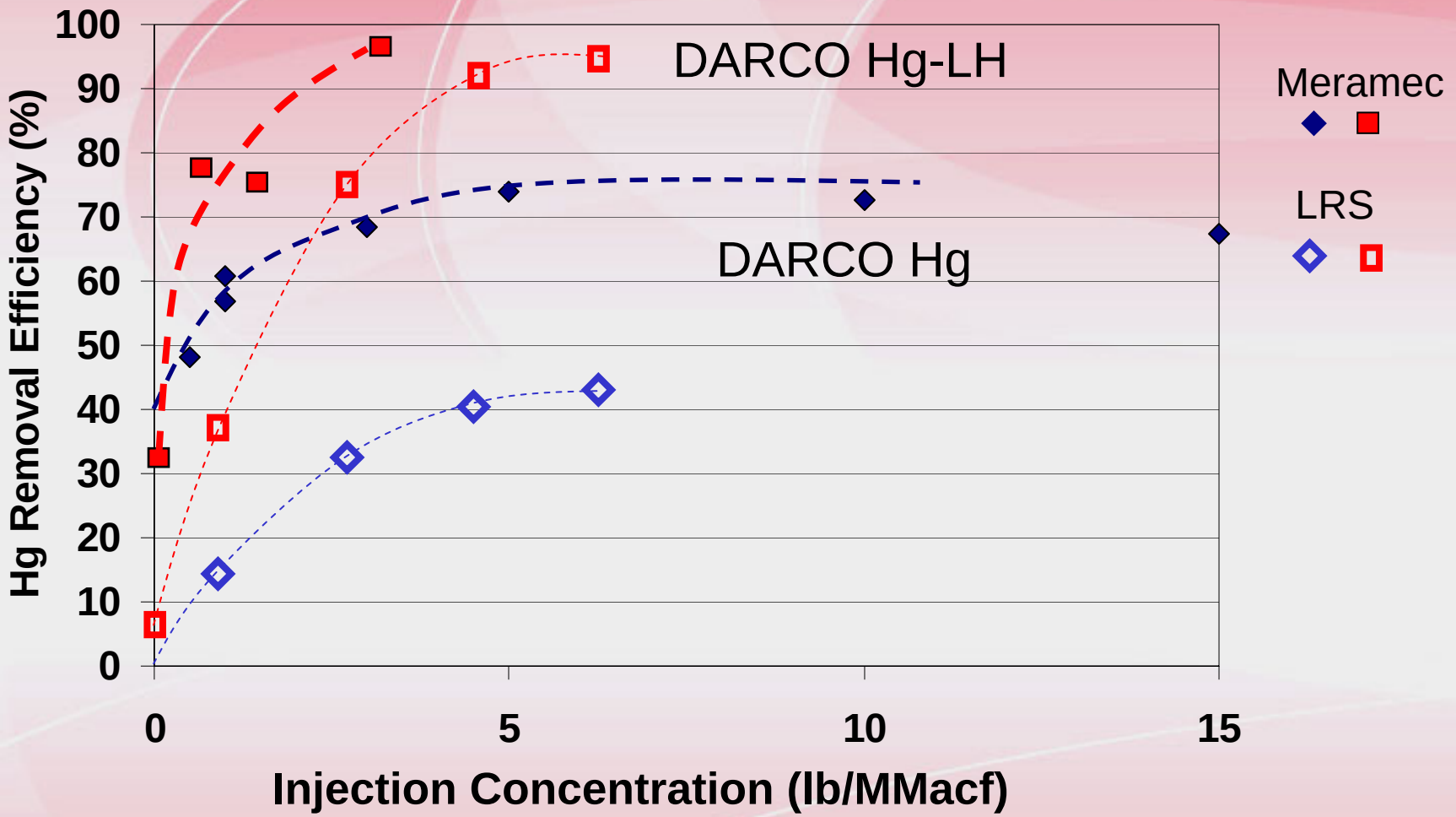
PRB/ESP Parametric Results



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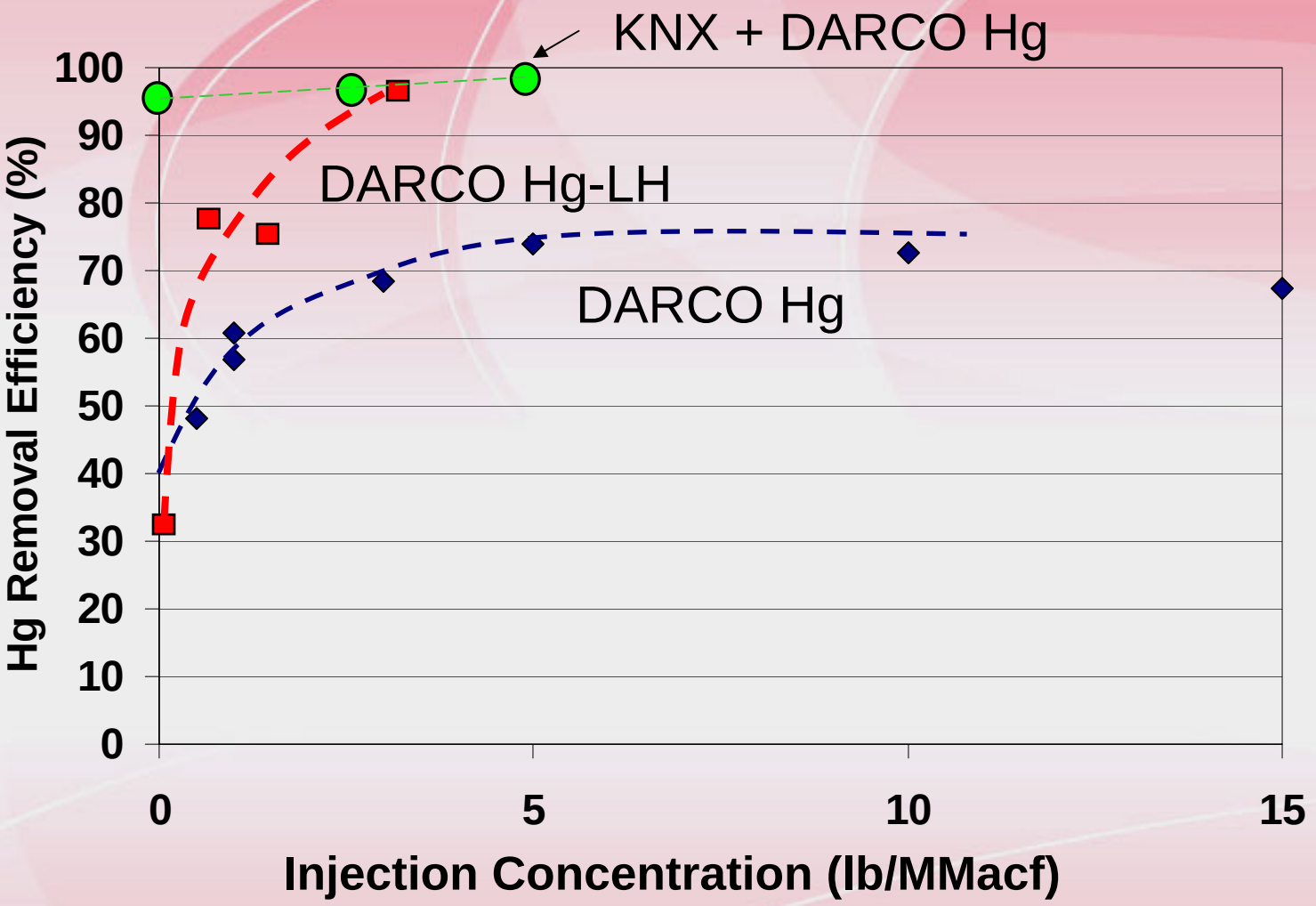
Meramec Parametric Results



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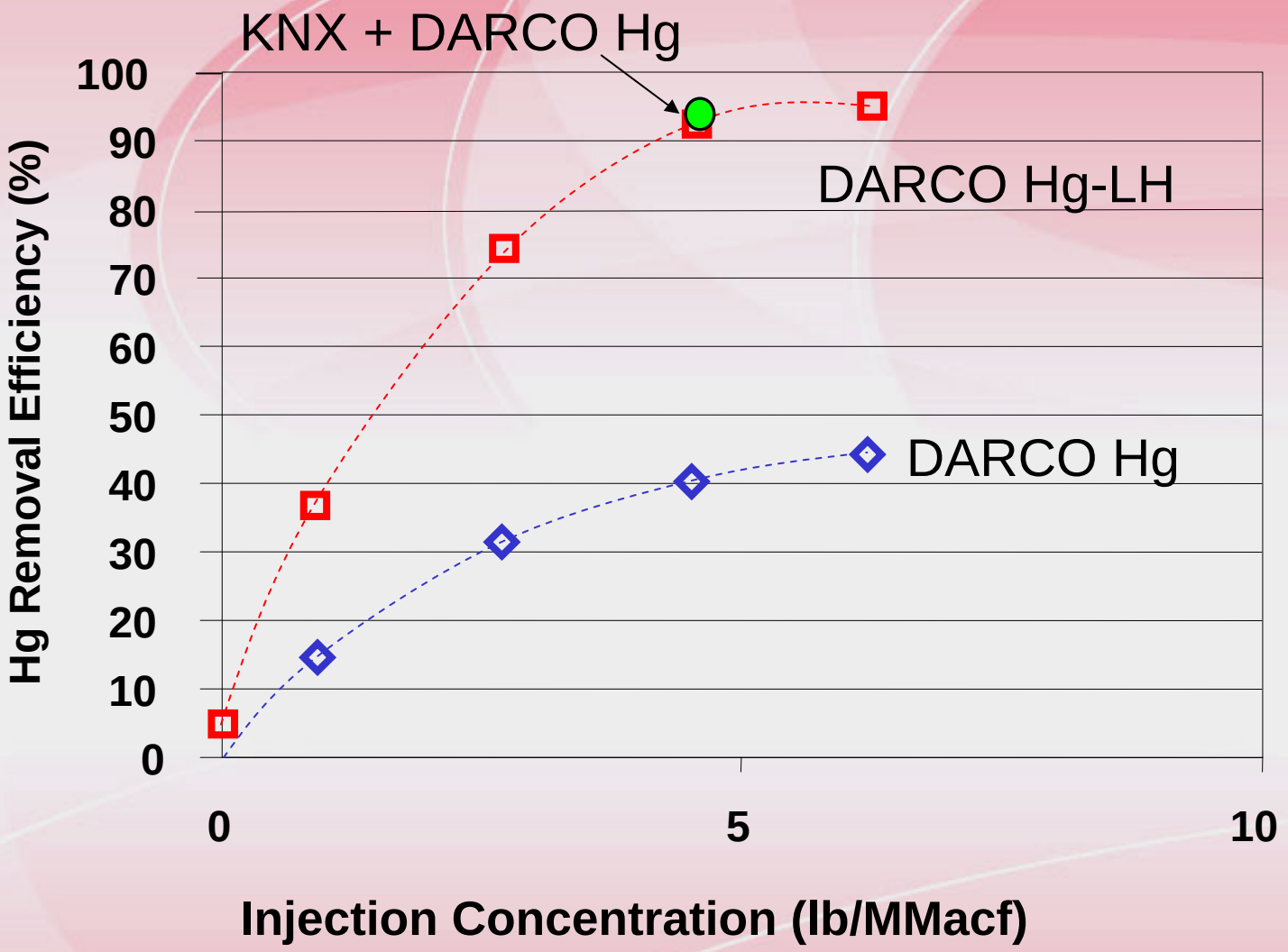
Laramie River Parametric Results



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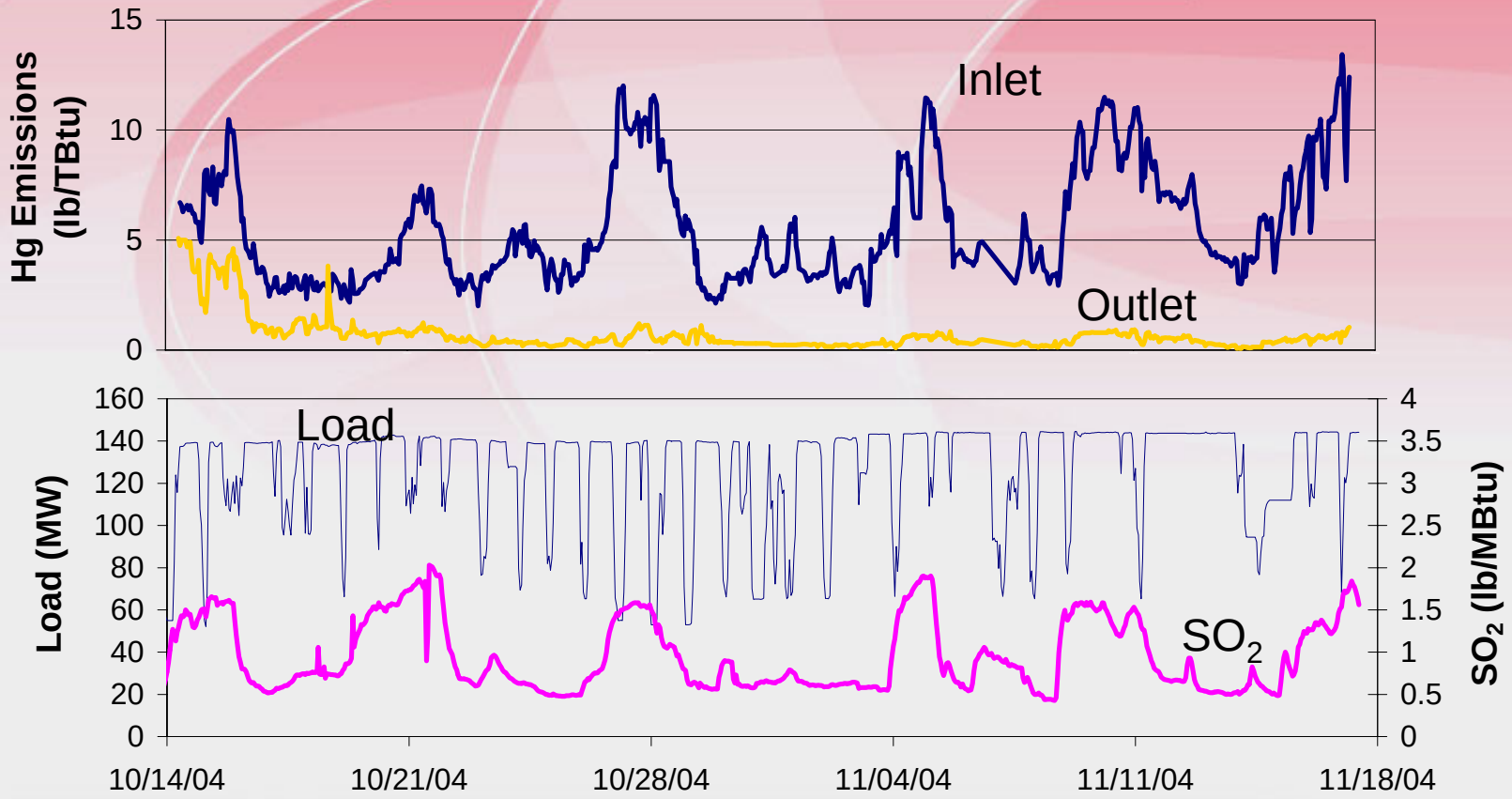
Long-Term Results
Meramec, DARCO Hg-LH



Average Hg Removal Efficiency: 93%

Sorbent Injection Concentration: 3.3 lb/MMacf

Average Hg emissions: 0.44 lb/TBTU

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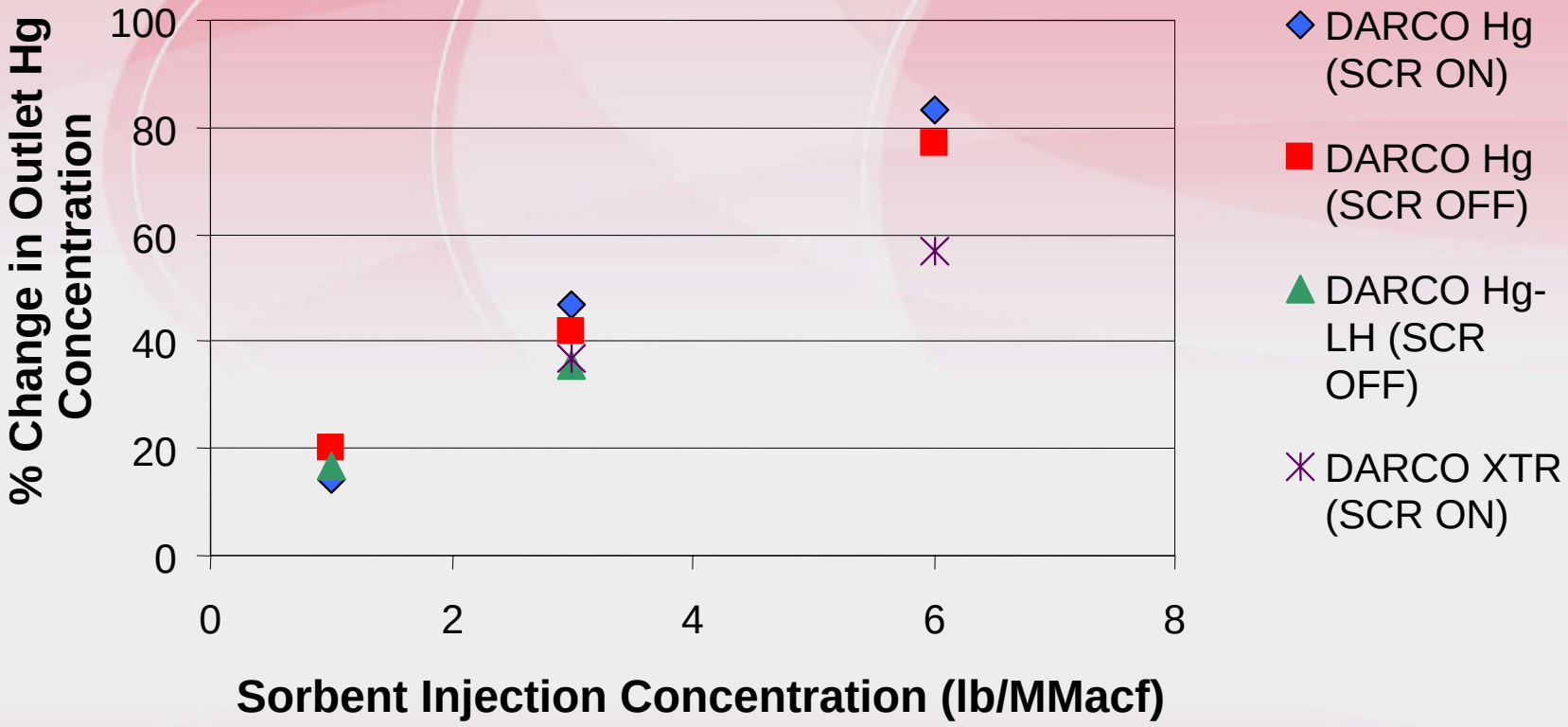
Monroe Preliminary Parametric Results



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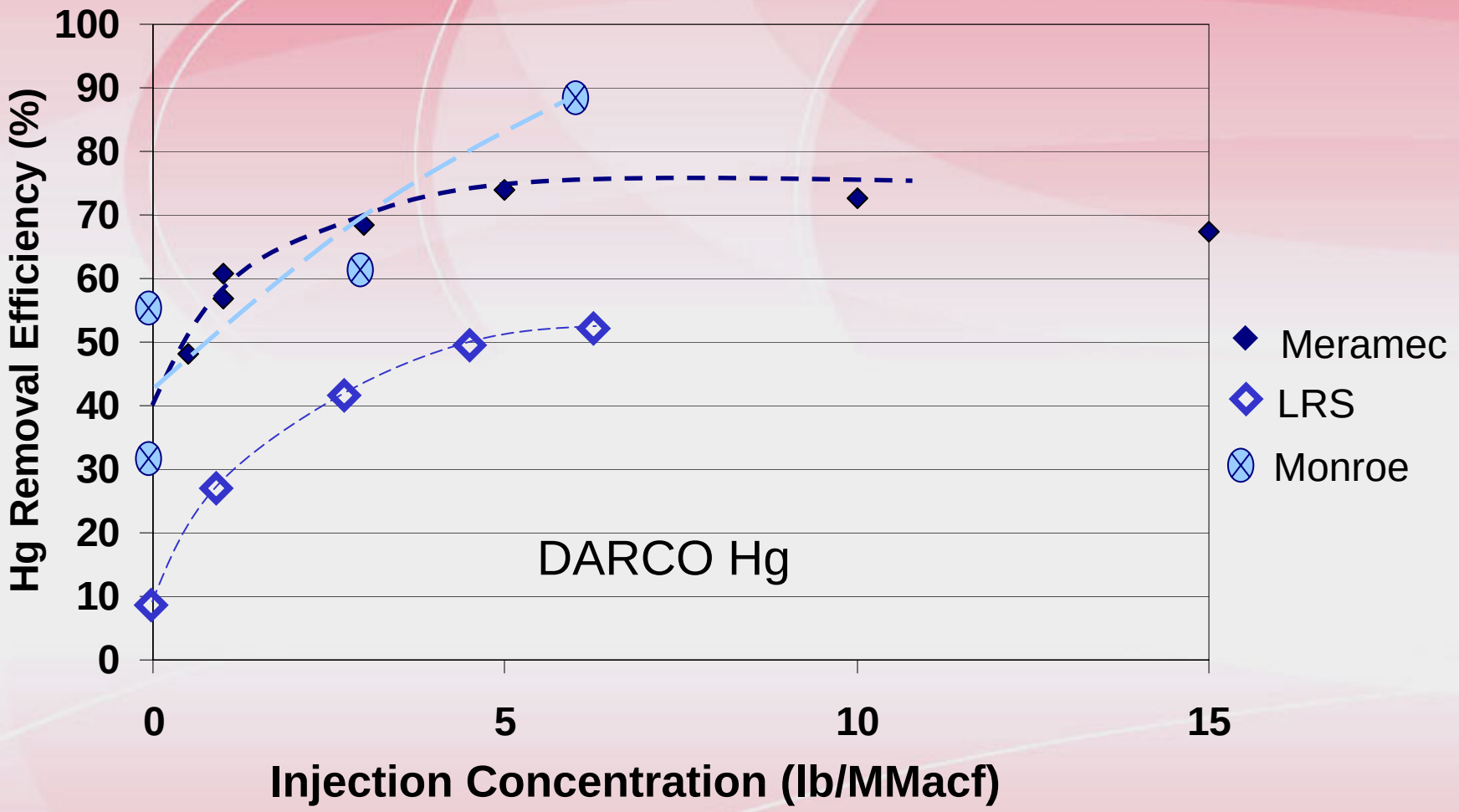
ESP Parametric Results Comparison



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Coal Blending to Improve Mercury Control

Sunflower Electric, Holcomb Station	Completed 2004
Basic Electric, Laramie River	Completed March 2005
Detroit Edison, Monroe Station	Completed March 2005

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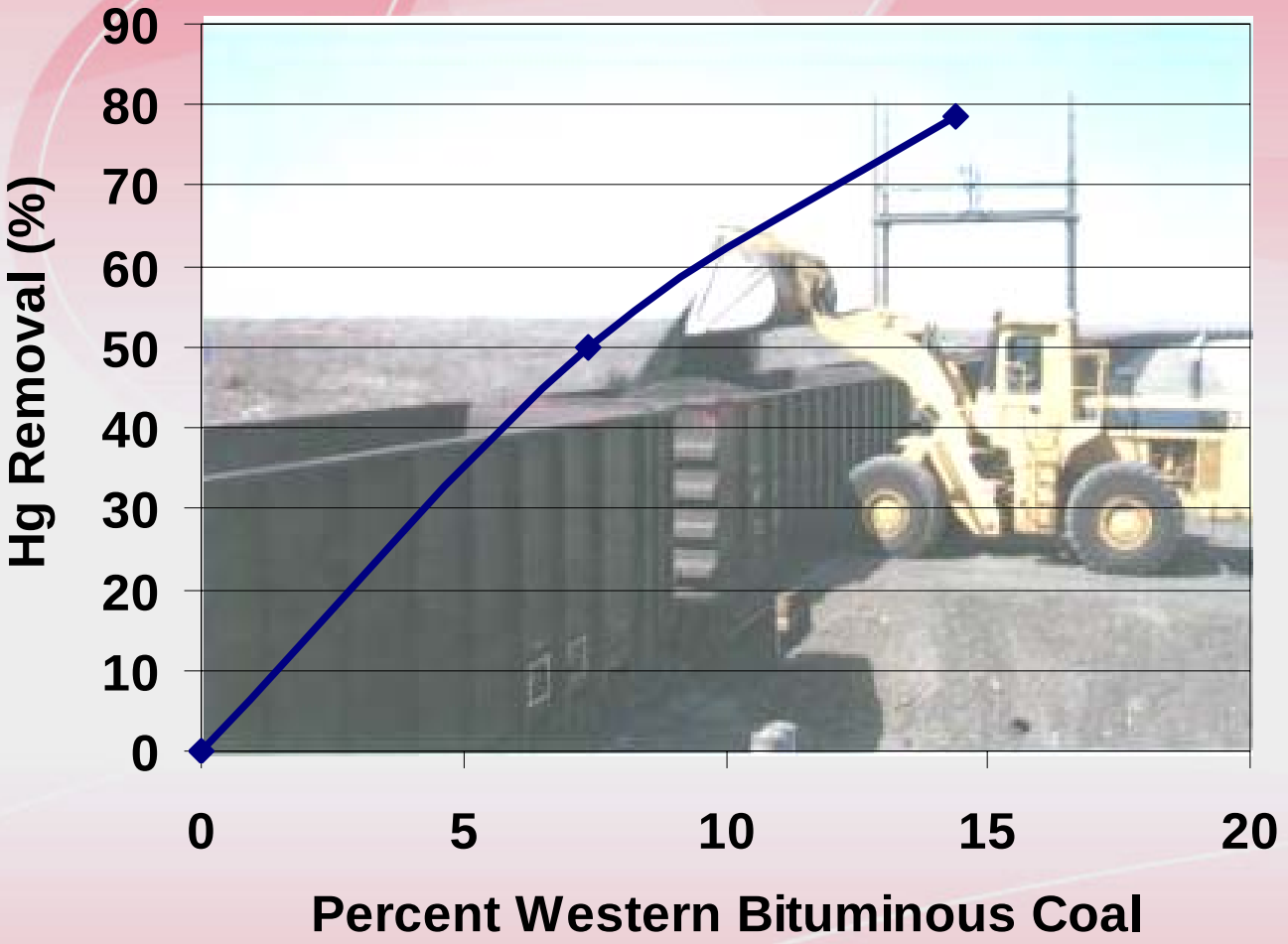
Coal Blending Results – Holcomb



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Laramie River Coal Blending Results

- Two Western Bituminous Coals Tested
  - Coal 1 – no improved mercury removal up to 80% PRB, 20% Bituminous
  - Coal 2 – minimal improvement (<10%) at 84% PRB, 16% Bituminous

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Monroe Coal Blending
Preliminary Results, SCR Bypassed

Blend Ratio (PRB/Bit)	ESP Inlet Total Vapor Phase Hg ($\mu g/dNm^3$)	ESP Inlet Vapor Phase Oxidized Mercury ($\mu g/dNm^3$)	% ESP Inlet Vapor Phase Oxidized Mercury
60/40	12.1	6.4	52
65/35	11.1	5.7	51
70/30	13.4	5.0	37

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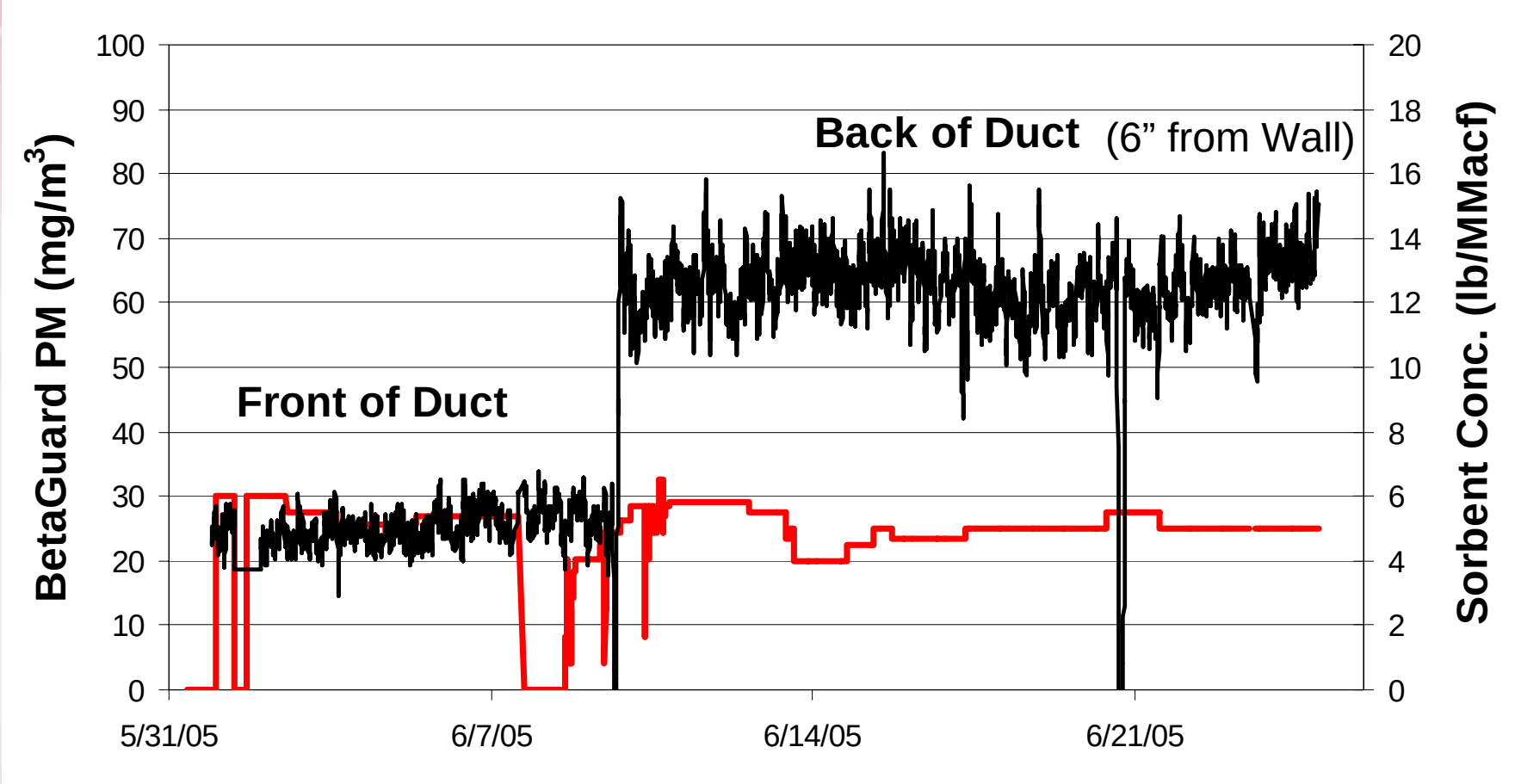
ESP Outlet Particulate Emissions



Baseline SCR ON: Front of Duct = 26.1 mg/m³ = 0.01 grains/dscf
Back of Duct = 59.9 mg/m³ = 0.024 grains/dscf

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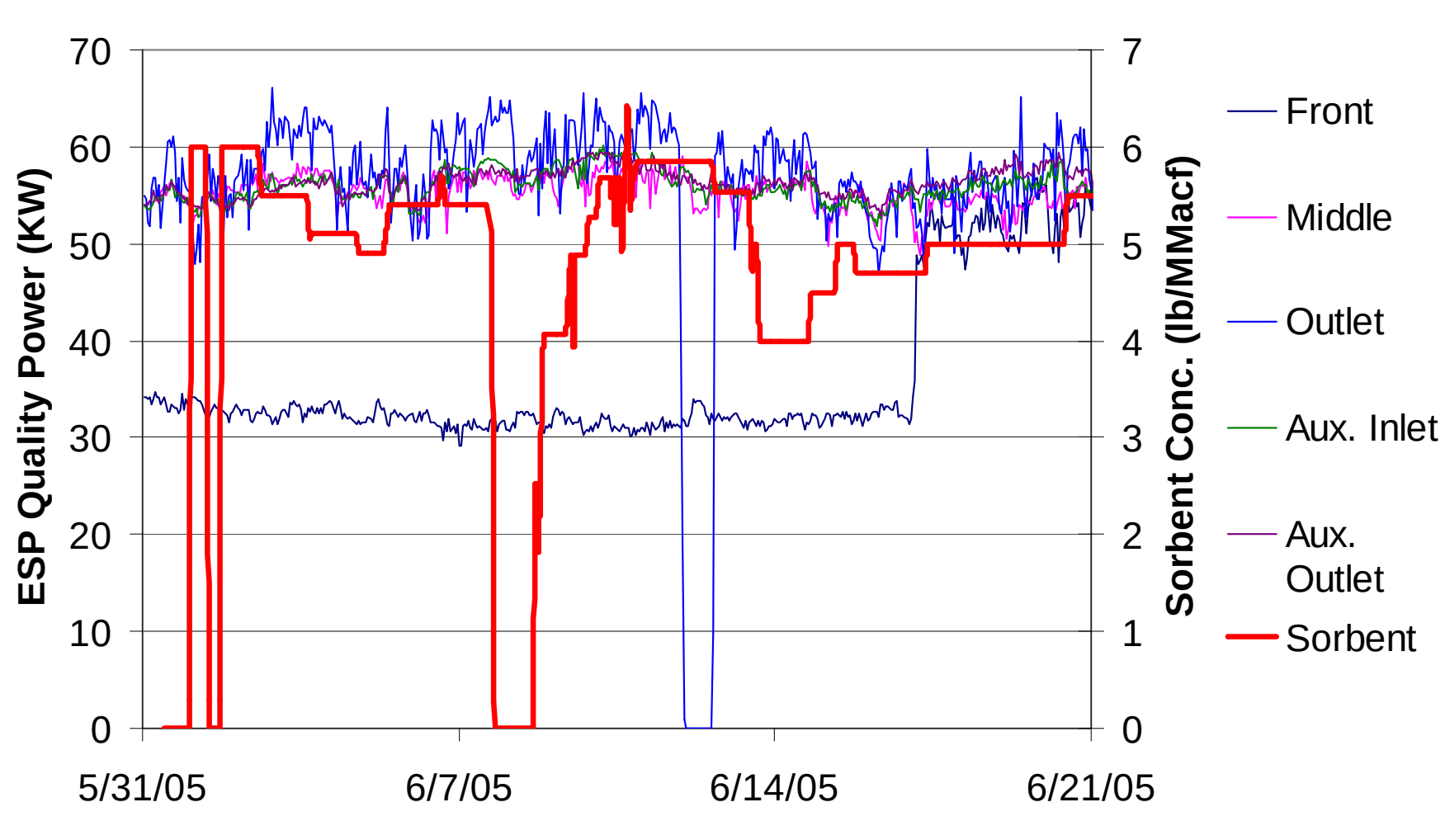
ESP Power During Sorbent Injection



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CCB and Other Issues

- The mercury captured by activated carbon, LOI carbon, and ash appears to be very stable and unlikely to reenter the environment.
- The presence of activated carbon in ash will most likely prevent sale for use in concrete.
  - Several developing technologies to address the problem
- Low level bromine leaching from ash mixed with treated carbon – *How significant is this?*
- No secondary stack emissions measured due to treated sorbent injection

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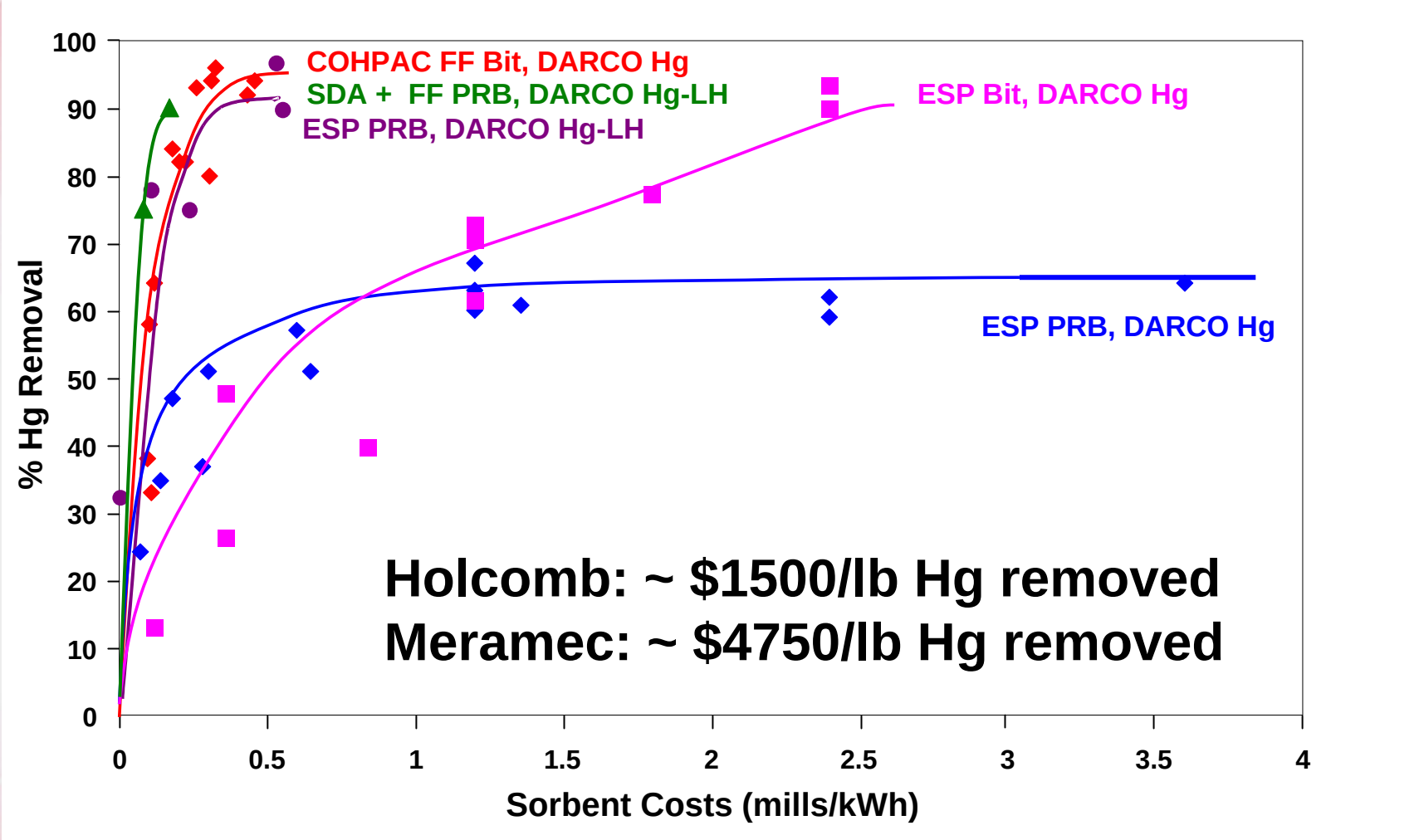
Sorbent Cost Comparison



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Options for Western Fuels: Summary

- Coal Blending
  - Up to 80% mercury removal achieved during short-term W. Bit. blend test at Holcomb
  - Little mercury removal noted at Laramie River up to 16% W. Bit.
  - Baseline removal at Monroe 7 to 35% (60/40 blend)
  - Higher oxidized mercury fraction at Monroe (~ 50%)
- Coal Additives
  - >80% removal achieved at Meramec without ACI *(plant configuration and high LOI may have contributed to removal)*
  - ACI required at Holcomb and Laramie River for high removal

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Options Summary (cont.)

- Treated Activated Carbon Injection
  - High removal achieved at Holcomb and Meramec
  - No Improvement noted at Monroe (60/40 Blend)
  - No adverse balance-of-plant impacts noted
- Maintaining Ash Sales
  - TOXECON™
  - TOXECON II™

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What's Next for DOE NETL & ADA-ES?

- TOXECON II™ testing, fall 2005
- Hot-Side ESP testing, fall 2005 and spring 2006
- Commercial TOXECON™ start-up, spring 2006
- Conesville testing, spring 2006
  - High sulfur E. Bit, ESP + FGD
  - New sorbents under development – *screening tests fall 2005*

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  Travis Starns (traviss@adaes.com)
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- Reaction Engineering: Connie Senior
- Alstom: Leif Lindau

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