Mercury Measurement and Control

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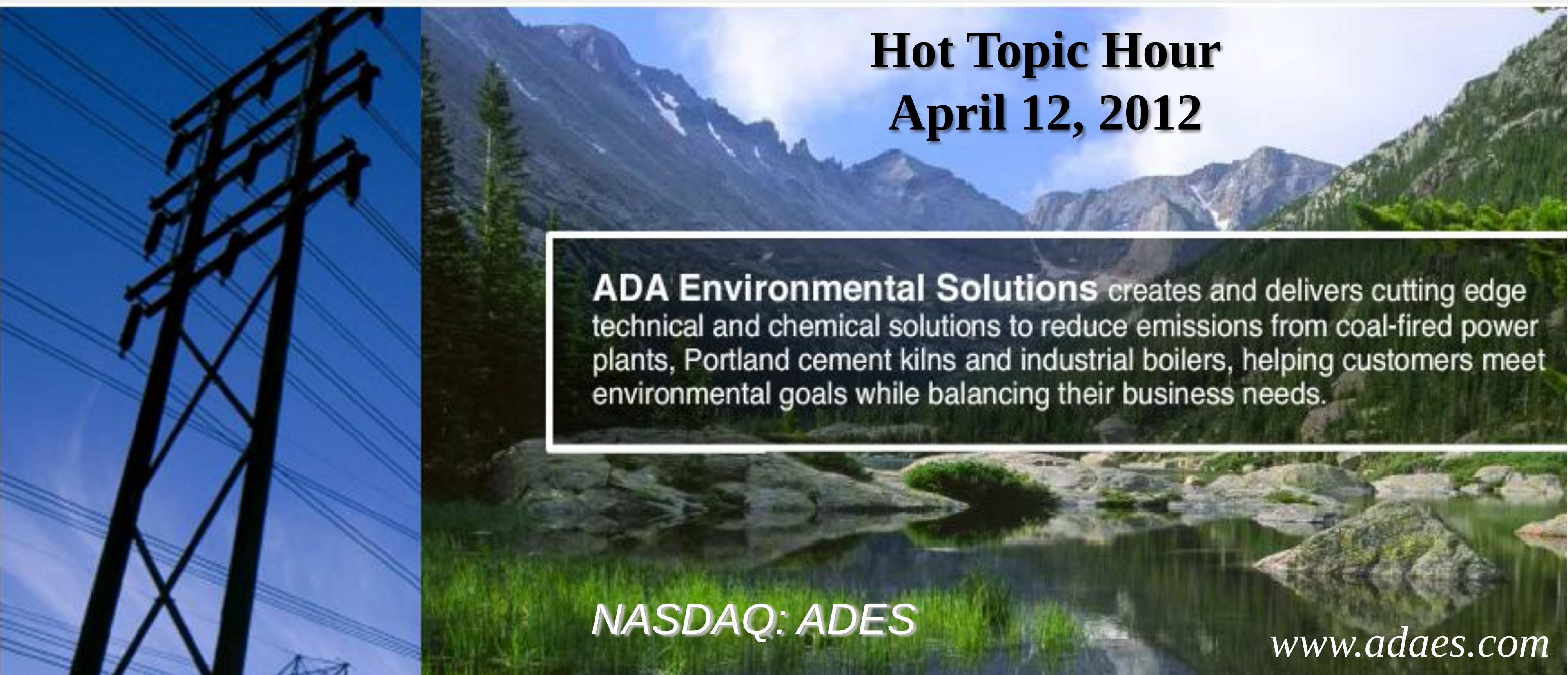


Topics to Cover

- Overview of MATS for existing & new plants
- Measurement of Hg
- Capabilities of available control technologies for mercury control
- Coal to Stack: Integrated approaches for multi-pollutant compliance

MATS Final Limits (Coal)

- Standards for new units are based on outputs

Subcategory	Filterable PM	HCl	Mercury
New coal, ≥8300 Btu/lb	**0.007 lb/MWh**	**0.0004 lb/MWh**	**0.0002 lb/GWh**
New coal, <8300 Btu/lb	**0.007 lb/MWh**	**0.0004 lb/MWh**	**0.040 lb/GWh**
Existing coal, ≥8300 Btu/lb	0.30 lb/MWh	0.020 lb/MWh	0.013 lb/GWh
Existing coal, <8300 Btu/lb	0.30 lb/MWh	0.020 lb/MWh	0.040 lb/GWh

- Standards for existing units are based on inputs
- Standards for new units (bituminous, subbituminous) are ~65 times lower than for existing units!

Mercury Measurement

- Continuous measurement of Hg required
  - CEM or Sorbent Trap
- Emissions averaging
  - For existing bituminous/subbituminous units, limit of 1.2 lb/TBtu (30-day average) or 1.0 lb/TBtu (90-day average)
- Facility-wide averaging for similar units
- Challenges in measuring very low levels of Hg

The Compliance Challenge

- **Integrated Decisions**
  - Multiple regulations. Decisions on one pollutant may affect options for others
  - Long-range, multi-plant CapEx decisions, fuel decisions
- **Tight Timeframes**
  - Implementation by 2015 for MATS and CSAPR
  - Rapid, informed decisions are now required
- **Limited Resources**
  - Testing Services, Engineering and Construction Services, APC Equipment, Chemicals

Fuel Choice Affects MATS Compliance

- Mercury inputs vary by region and by mine within a region
  - MATS sets limits on Hg emissions, not percent reduction
  - The bar is higher (for control) when Hg input is higher
- SO_2 and HCl emissions might also have to be controlled under MATS (or CSAPR)
- Sulfur and chlorine in coal affect ability to reduce Hg emissions
- *Finding the perfect MATS coal…?*

MATS Compliance Limits: Example for Existing Bituminous Plant

Final MACT Limits:

PM, lb/MMBtu	HCl, lb/MMBtu	SO_2, lb/MMBtu[1]	Hg, lb/TBtu
0.03	0.002	0.2	1.2

Estimated control efficiency, based on fuel:

HCl	SO_2[1]	Mercury
98%	97%	86%

[1]Alternate acid gas limit for units with scrubbers
[2]Concentrations at 3% O_2

INPUT COAL PROPERTIES

	As-received coal composition				Dry coal composition	
Coal Rank	Coal S, wt%	Coal Ash, wt%	Coal HHV, Btu/lb	Coal H_2O, wt%	Coal Cl, µg/g	Coal Hg, µg/g
Bituminous	3.60%	10.30%	11,011	3.30%	1000	0.1

Factors Affecting Mercury Control

- Coal Type
  - Halogen content (Cl, Br, other)
  - Sulfur content
  - Mercury content
- Flue Gas
  - Acid Gases (HCl, SO_2, SO_3)
  - Gas Temperature

Similar factors affect Hg removal from native carbon in ash and activated carbon injection

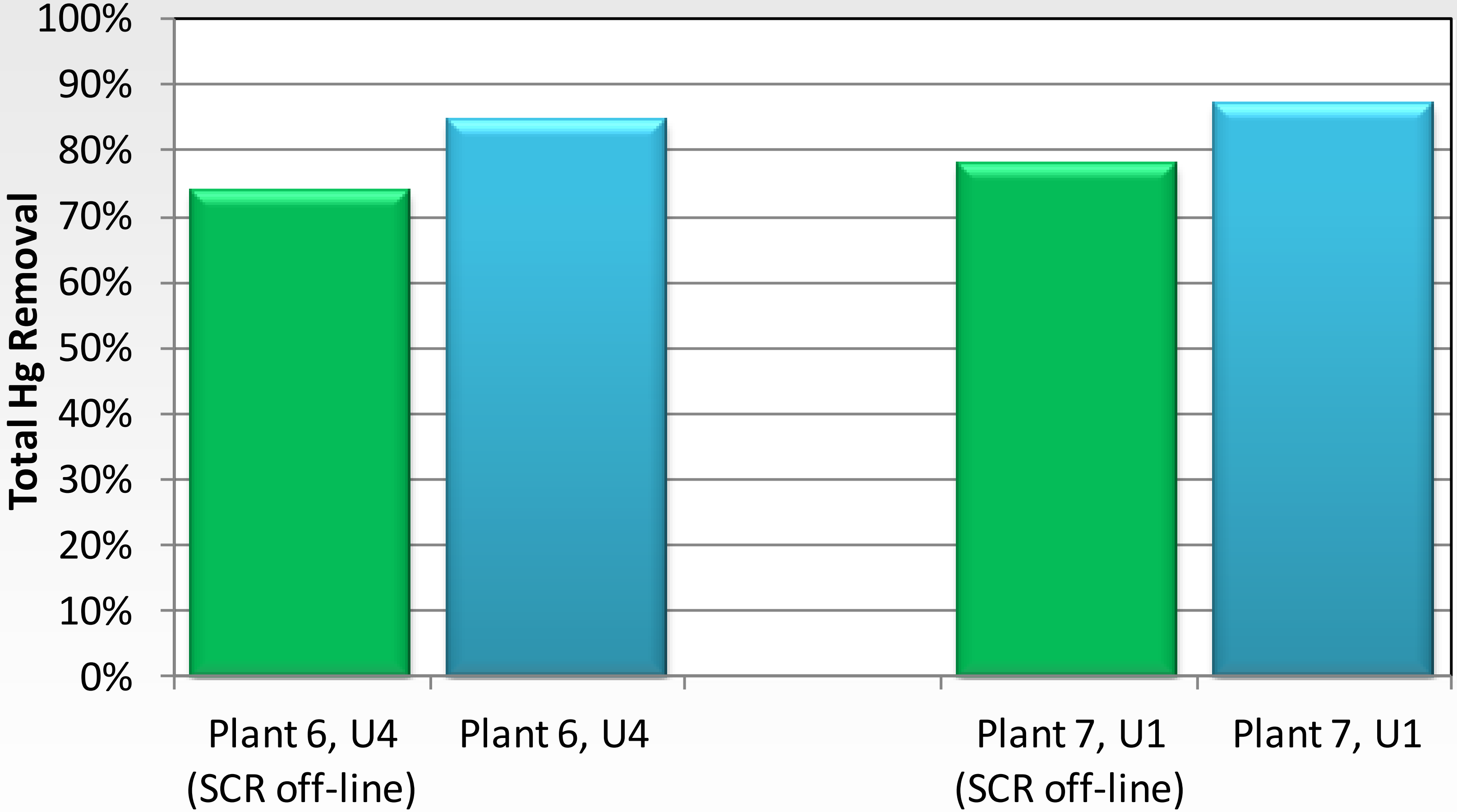
- Boiler type
- Emission Control Equipment (e.g. SCR, ESP, FF, etc.)
- ACI Design
  - Distribution, residence time, sorbent characteristics

Native Mercury Removal (Average %): The Good, the Bad, and the Ugly…

	Bituminous	Subbit.	Lignite
CSESP	41	17	-2
+ WFGD	73	21	45
HS ESP	22	14	
+ WFGD	44	25	
FF	87	71	
+ WFGD	78		
SDA + FF	95	31	29
SDA + ESP	50	50	
WPS	14	-2	30
Projected for MATS	*80-90$^+$*	*80-90$^+$*	*60-90$^+$*

Analysis of 1999 EPA ICR data

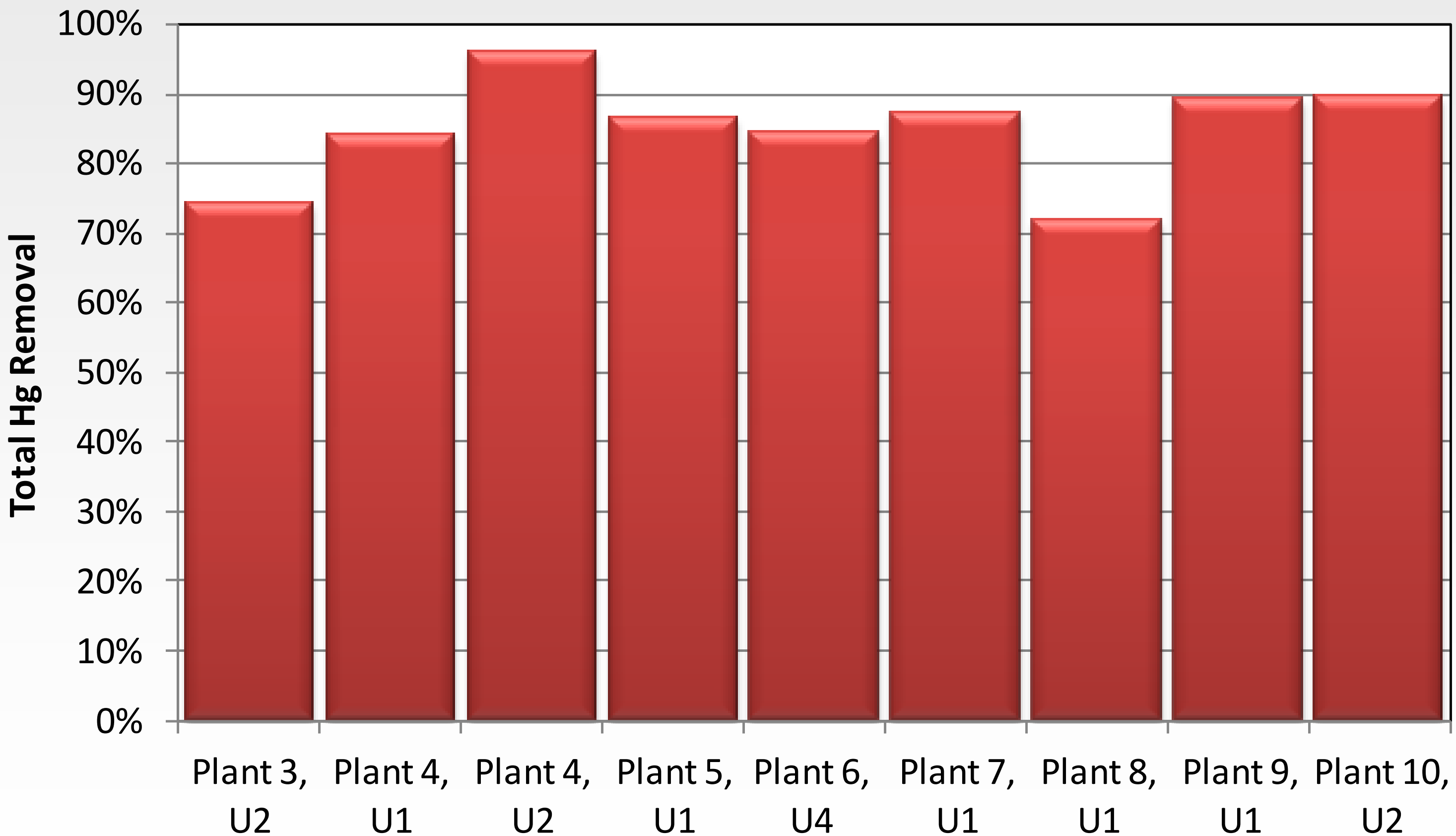
SCR plus FGD Increases Hg Removal



Source: Bituminous-fired plants from Consol sampling program

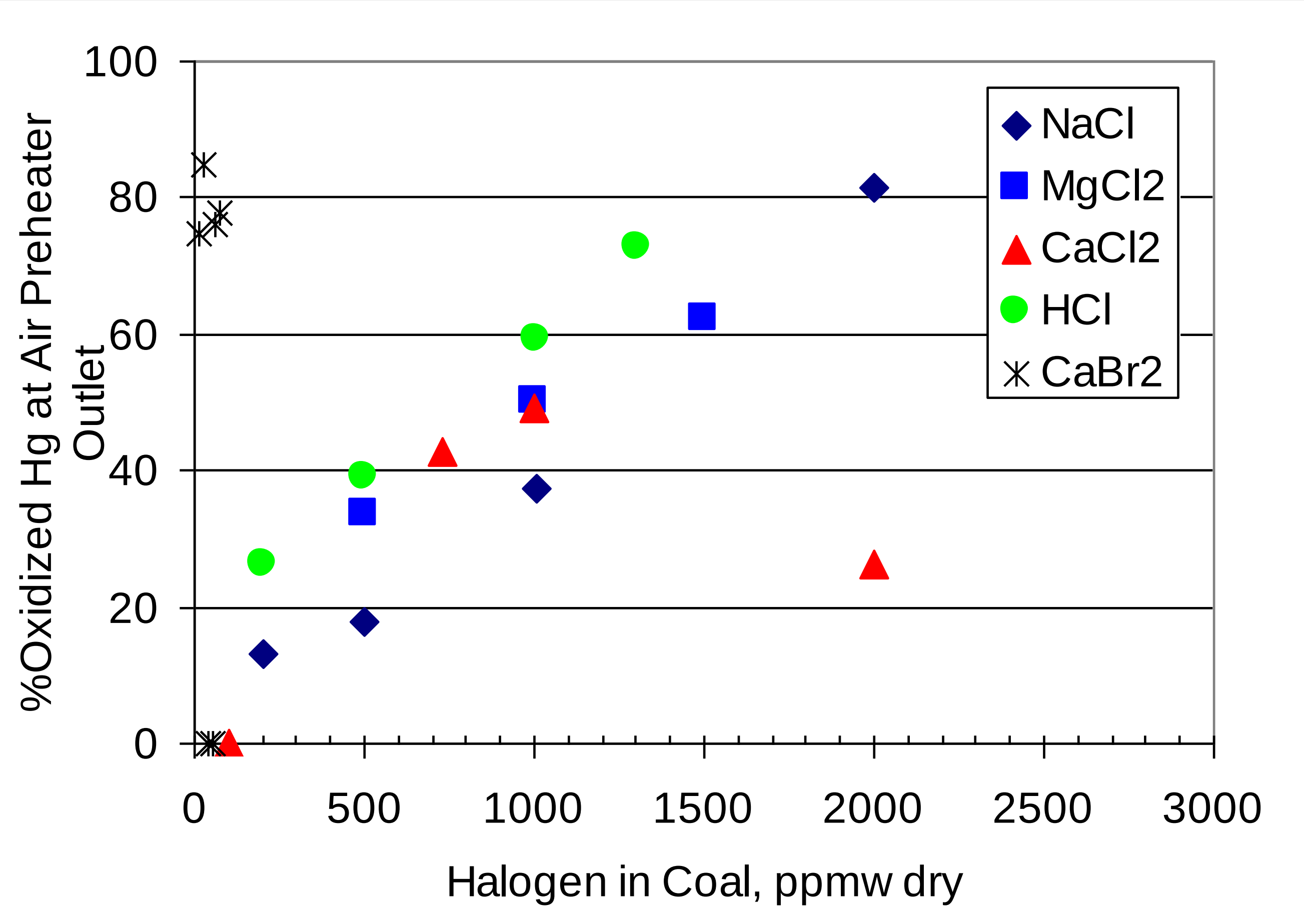
SCR-FGD Reduces Hg Emissions

…but >90% removal not always achieved and trim control with ACI might be needed



Source: Bituminous-fired plants from Consol sampling program

Halogens Increase Oxidized Mercury

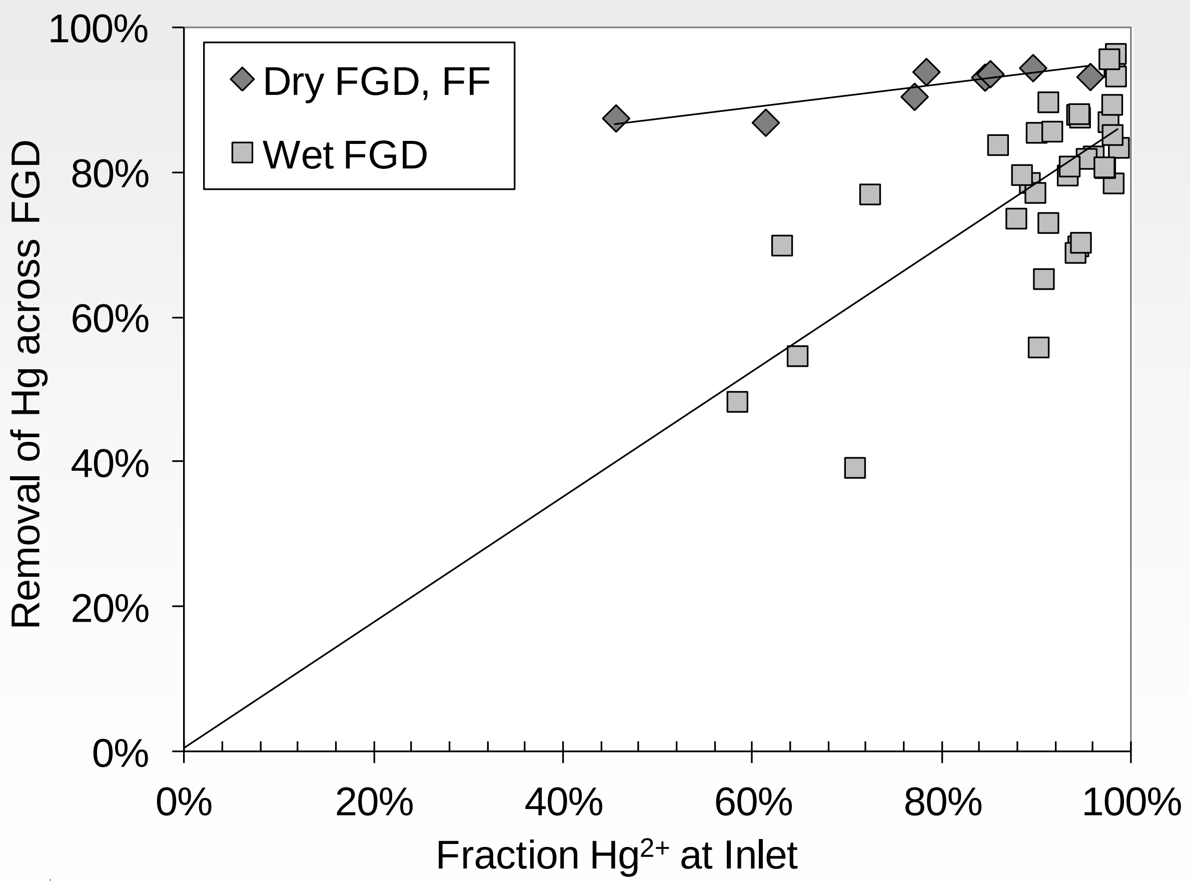


Halogen addition at various full-scale PRB boilers

Source: Dombrowski et al., 2006

Benefits of Oxidized Mercury

Many plants' APCDs can take advantage of native capture…if there's enough oxidized Hg (Hg^{2+})

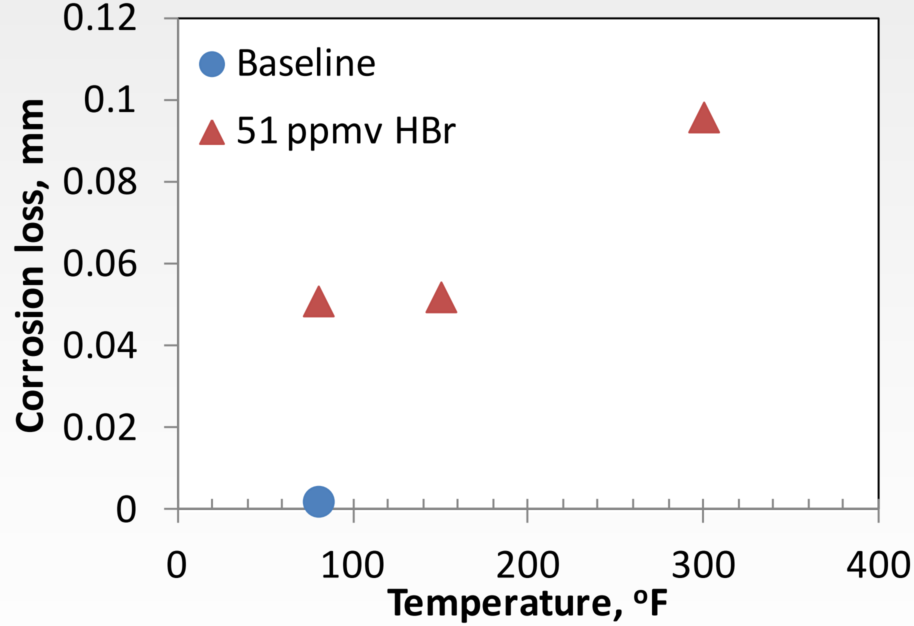


Halogens in Wet Scrubbers

- Adding halogens (Cl or Br) increases oxidized Hg, which increase capture of Hg in scrubber
- Wet FGD scrubbers remove halogens efficiently
  - Average Cl removals for wet FGDs (2010 ICR): 81% for subbituminous, 97% for bituminous
  - Removal of Br at Plant Miller wet FGD: 94-96% (Dombrowski et al., 2008)
- Halogens build up in wet scrubber liquor

Corrosion in Flue Gas

- Chlorine corrosion in furnaces can occur for very high levels of chlorine in coal (> 2000 µg/g)
  - Bromine addition at much lower concentrations
- Indirect evidence that HBr might be more corrosive than HCl at flue gas temperature
- No direct comparison, but HBr corrosion higher than baseline (no HBr) in simulated flue gas (6-month study)



Zhuang et al., 2009

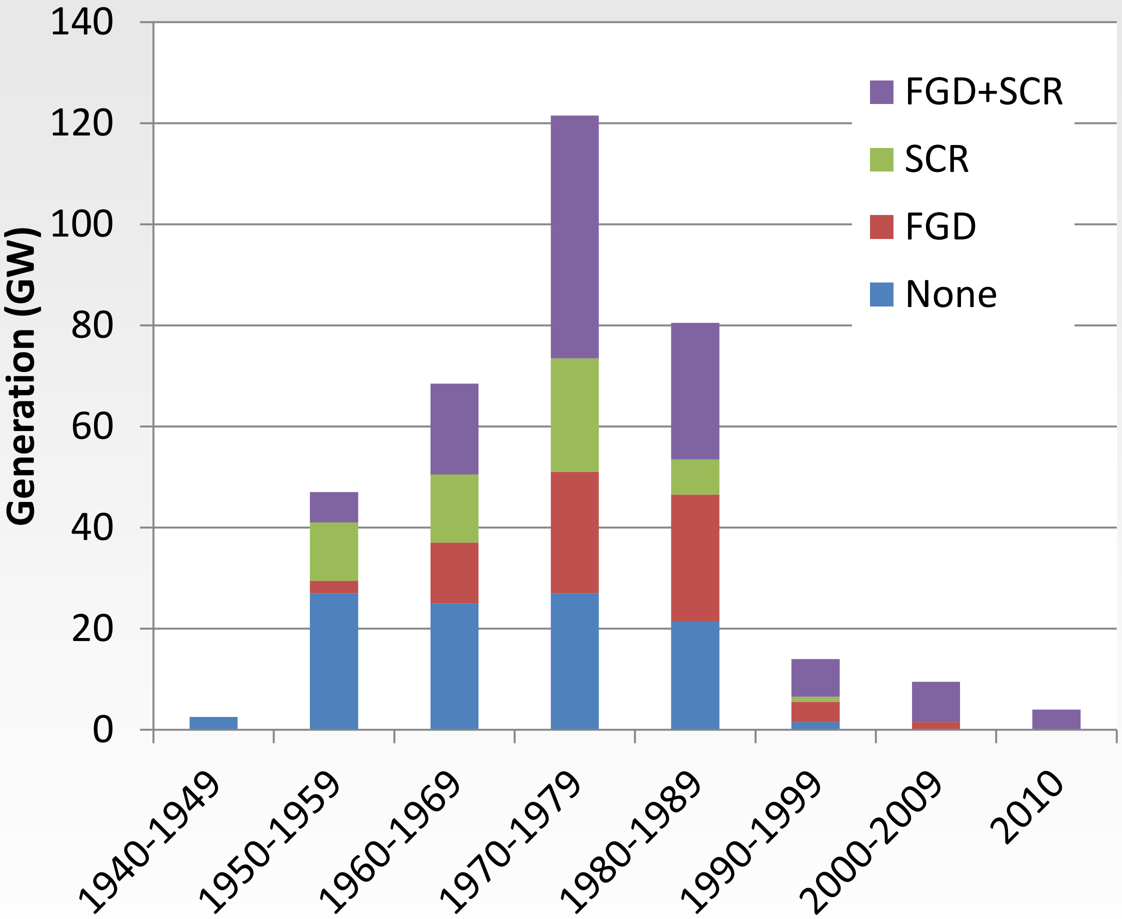
US Coal-Fired Generation Fleet

More than 1100 units in operation
~ 317 GW

~ 66% have SO_2 or NOx controls

Unscrubbed units

- ~ 50 GW bituminous
- ~ 60 GW subbituminous



*http://www.eia.gov

Activated Carbon Injection

Configuration	Range of AC for 90% Control (lb/MMacf)
PRB/SDA/FF	1 to 3
PRB/Toxecon	2 to 4
Bit/Toxecon	2 to not achieved
PRB/ESP	2 to not achieved
Bit/ESP	2.5 to not achieved

EPA Estimates 141 GW new ACI

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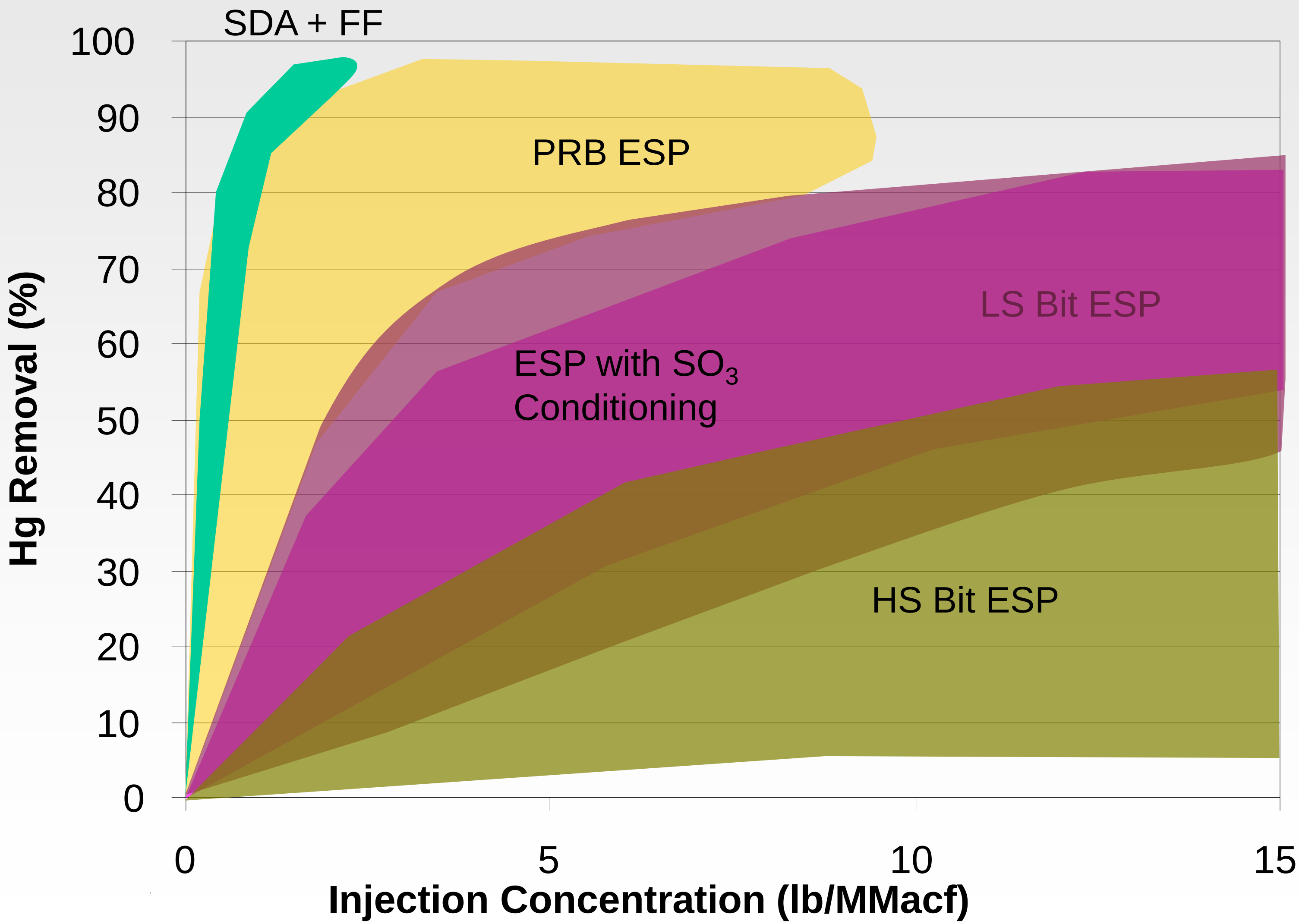
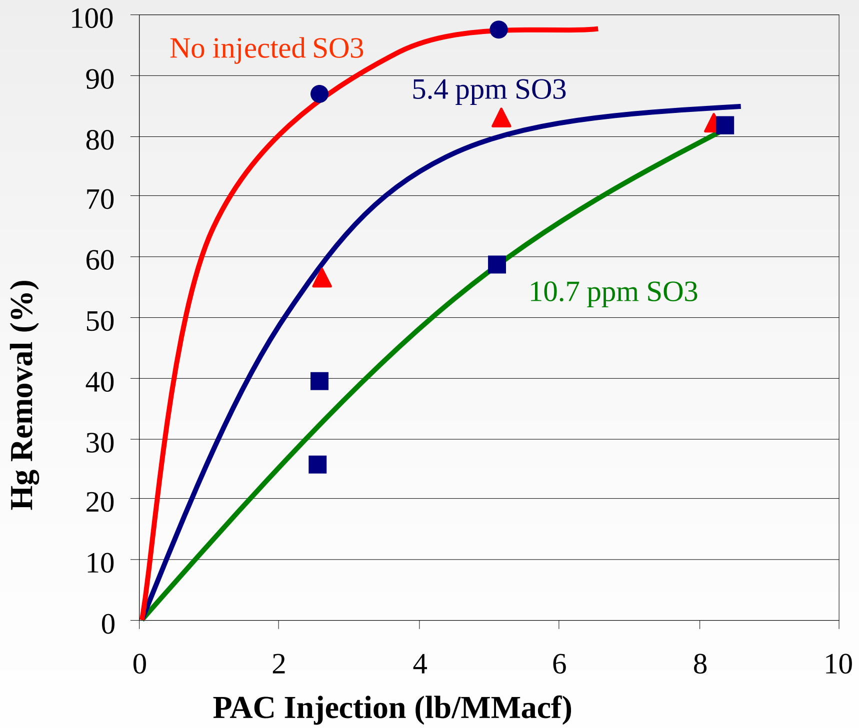
Activated Carbon Injection Performance Depends on Fuel Choice

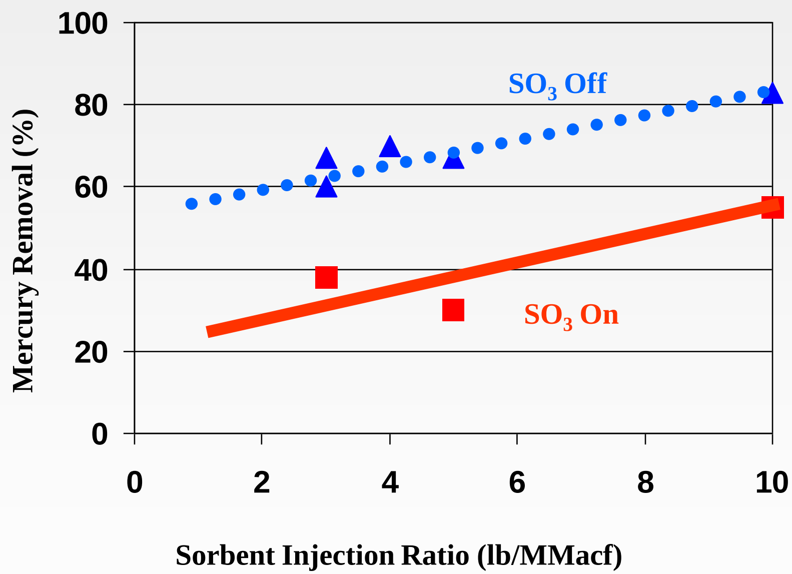


SO_3 Injection and PAC Effectiveness

- Any SO_3 in gas phase appears to affect Hg capture
  - SO_3 is used to condition fly ash for better capture in ESPs
  - SO_3 higher in bituminous flue gas, especially after SCR
- Typical injection targets < 10ppm in gas phase



Ameren Labadie Data: DOE DE-FC26-03NT41986 and EPRI PRB, ESP



Mississippi Power Plant Daniel
Low sulfur bituminous coal

Compliance Strategies for Mercury

- 80 to >90% control at the stack to meet proposed MATS emission limits required for most units
- For units with FGD/SCR:

  Low conversion SCR catalyst and minimize ammonia slip

  Minimize re-emission of Hg^0 from wet FGD
- MATS limits achievable with ACI or ACI + coal additives on most subbituminous units if SO_3 flue gas conditioning (FGC) is eliminated
- MATS limits may be challenging on units with higher sulfur coals and may require SO_3 mitigation

Coal to Stack: Integrated Approaches for Multi-Pollutant Compliance

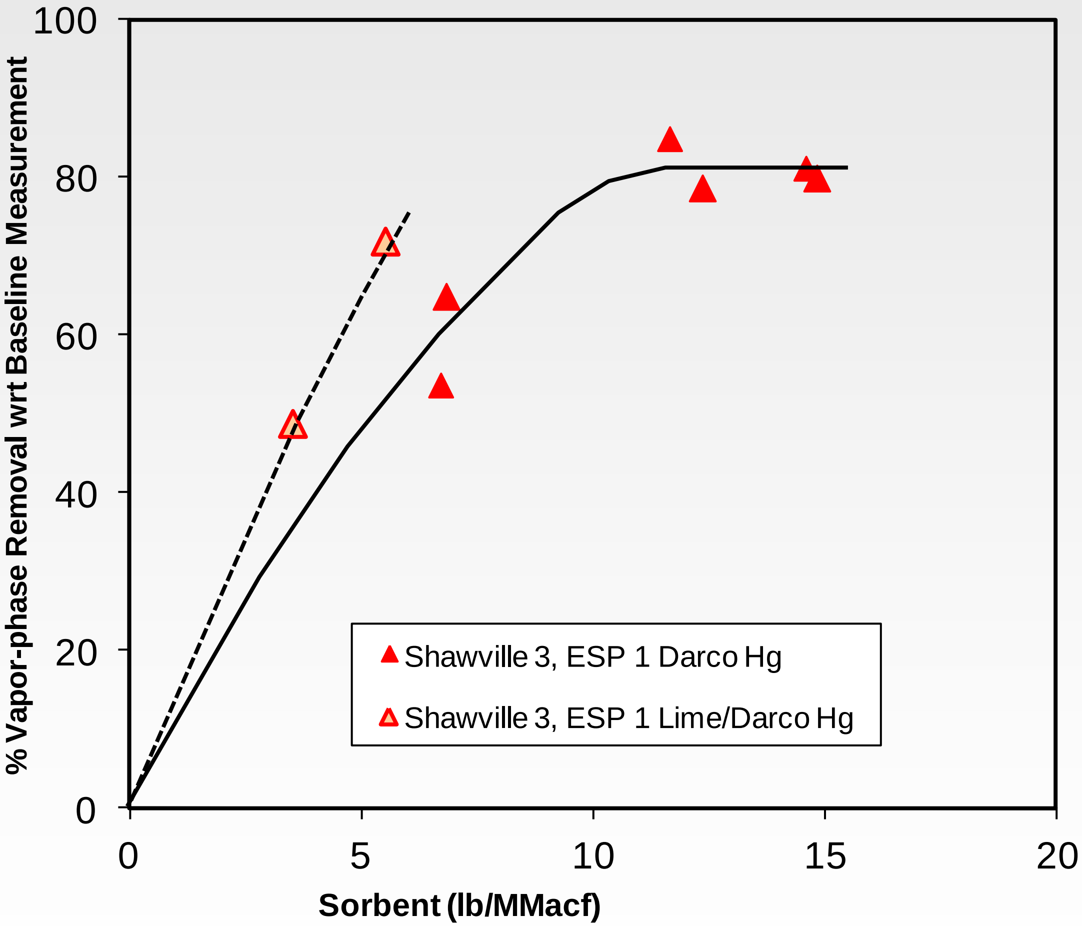
Examples:

- Fuel (low mercury, low sulfur, low chlorine)
- DSI as required to meet HCl limits and/or control SO_3 to maximize ACI effectiveness
- Manage SCR operation and catalyst choice to increase fraction of oxidized mercury and resulting removal in WFGD
- Utilize coal additives to manage ACI usage and Hg removal effectiveness

DSI-ACI Synergy: Example

Medium-sulfur bituminous plant

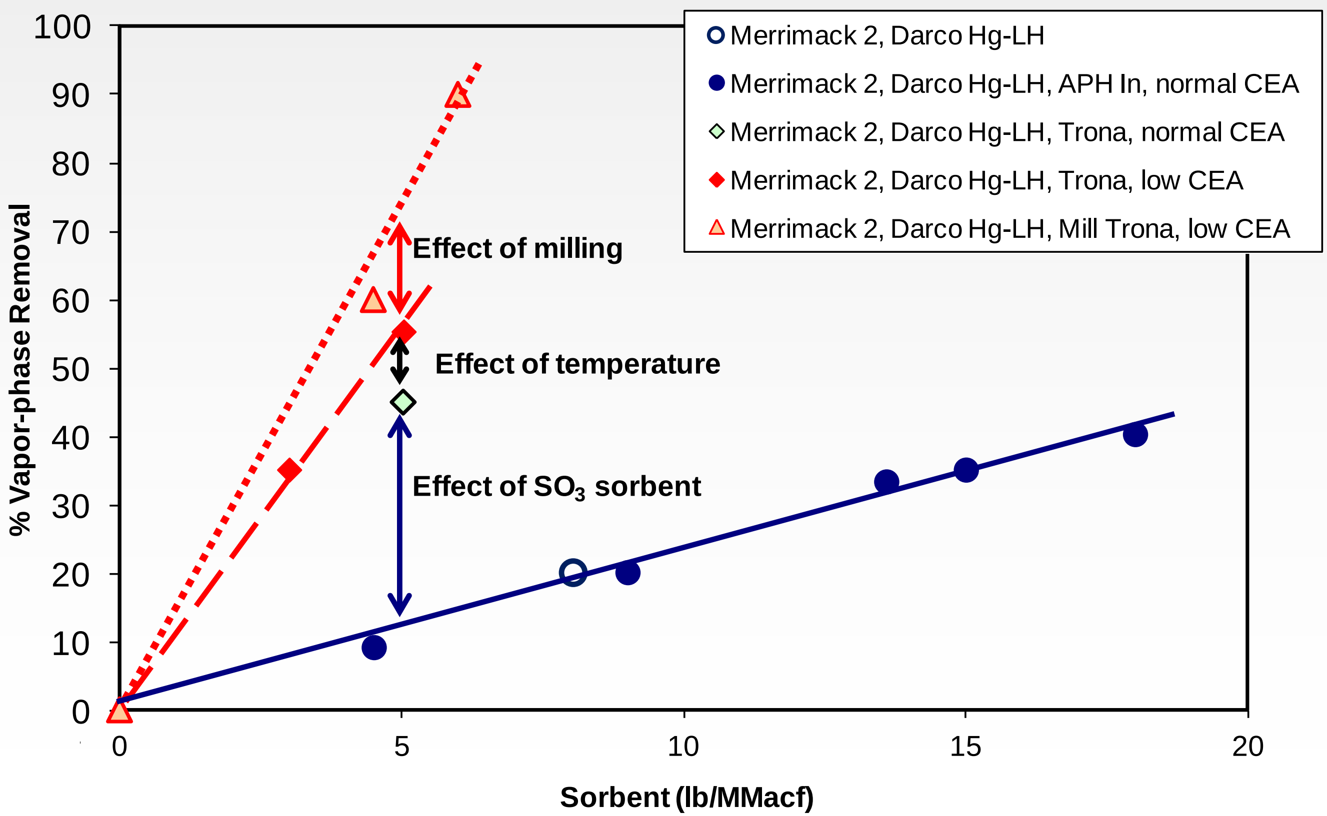
Lime injection to reduce SO_3 => improve ACI performance for Hg control



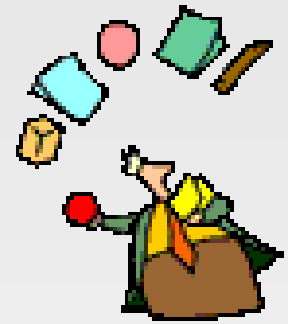
DSI-ACI Synergy: Example

Low-sulfur bituminous plant with SCR

Trona injection to reduce SO_3 => improve ACI performance for Hg control



Summary: The Multi-Pollutant View



- Mercury
  - 80 to >90% control required for most units
  - Achievable on most subbituminous units if SO_3 FGC is eliminated
  - Limits may be challenging on units with higher sulfur coals and may require SO_3 mitigation
- HCl
  - > 90% control required for most bituminous units. May require new scrubbers for some units.
  - < 80% control required for most plants with low-rank coals. Should be achievable with fuel management, DSI or existing FGD for most plants.
- Total PM
  - May result in several new fabric filters

Energizing the Future with Cleaner Coal

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