Low CapEX Solutions for Compliance with Industrial Boiler MACT

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Key Points of This Presentation

- ICI Boiler MACT is a *multi-pollutant regulation* with limits for mercury, HCl, particulate matter, and carbon monoxide
- ICI Boiler MACT solutions for solid fuels:
  - Finding a low-cost solution for multiple pollutants is highly desirable: Hg, HCl, PM
  - Integration of sorbent injection with particulate control can provide control of both mercury and HCl
  - Sorbent selection and system design are critical

ICI Boiler Emission Limits

- Hg and HCl emissions are fuel-specific, therefore all solid fuels (Coal and Biomass) have the same limits
  - Gas and liquid fuels have separate limits
- PM and CO are equipment-specific, so limit depends on the type of combustion system and the fuel
- Dioxin/furan emissions regulated under at work practice standard

ICI Boiler Limits: How Do They Compare with Electric Utility Limits?

- Example: Coal-Fired Stoker, Bituminous Coal

Boiler MACT Limits:

PM, lb/MMBtu	HCl, lb/MMBtu	Hg, lb/Tbtu
0.028	0.022	3.1

Estimated emission at Boiler MACT Limit:

Filterable PM[1], gr/dscf	HCl[1], ppmvd	Mercury[1], µg/dscm
0.017	20.0	4.3

Estimated control efficiency, based on fuel:

HCl	Mercury
19%	65%

Utility MATS Limits:

PM, lb/MMBtu	HCl, lb/MMBtu	Hg, lb/Tbtu
0.03	0.002	1.2

Estimated emission at Utility MATS Limit:

Filterable PM[1], gr/dscf	HCl[1], ppmvd	Mercury[1], µg/dscm
0.018	1.8	1.6

Estimated control efficiency, based on fuel:

HCl	Mercury
98%	86%

[1]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

The Compliance Challenge

- **Integrated Decisions**
  - Multiple regulations. Decisions on one pollutant may affect options for others
- **Tight Timeframes**
  - Many capital decisions must be made 2 to 3 years before implementation
- **Limited Resources**
  - Testing Services, Engineering and Construction Services, APC Equipment, Chemicals

Low CapEX Choices for ICI Boilers

- Units with hot-side ESP or Cyclones
  - No clear low capital options (mercury driver). A downstream fabric filter (TOXECON™) may be required.
  - Possible Hot-to-Cold Side ESP conversion
- Units with cold-side ESPs and Fabric Filters
  - Fuel (low mercury, low sulfur, low chlorine)
  - DSI as required to meet acid gas limits
  - Maximize ACI effectiveness
    - Minimize SO_3
      (DSI to mitigate or use alternative FGC)

Factors Affecting Mercury Control

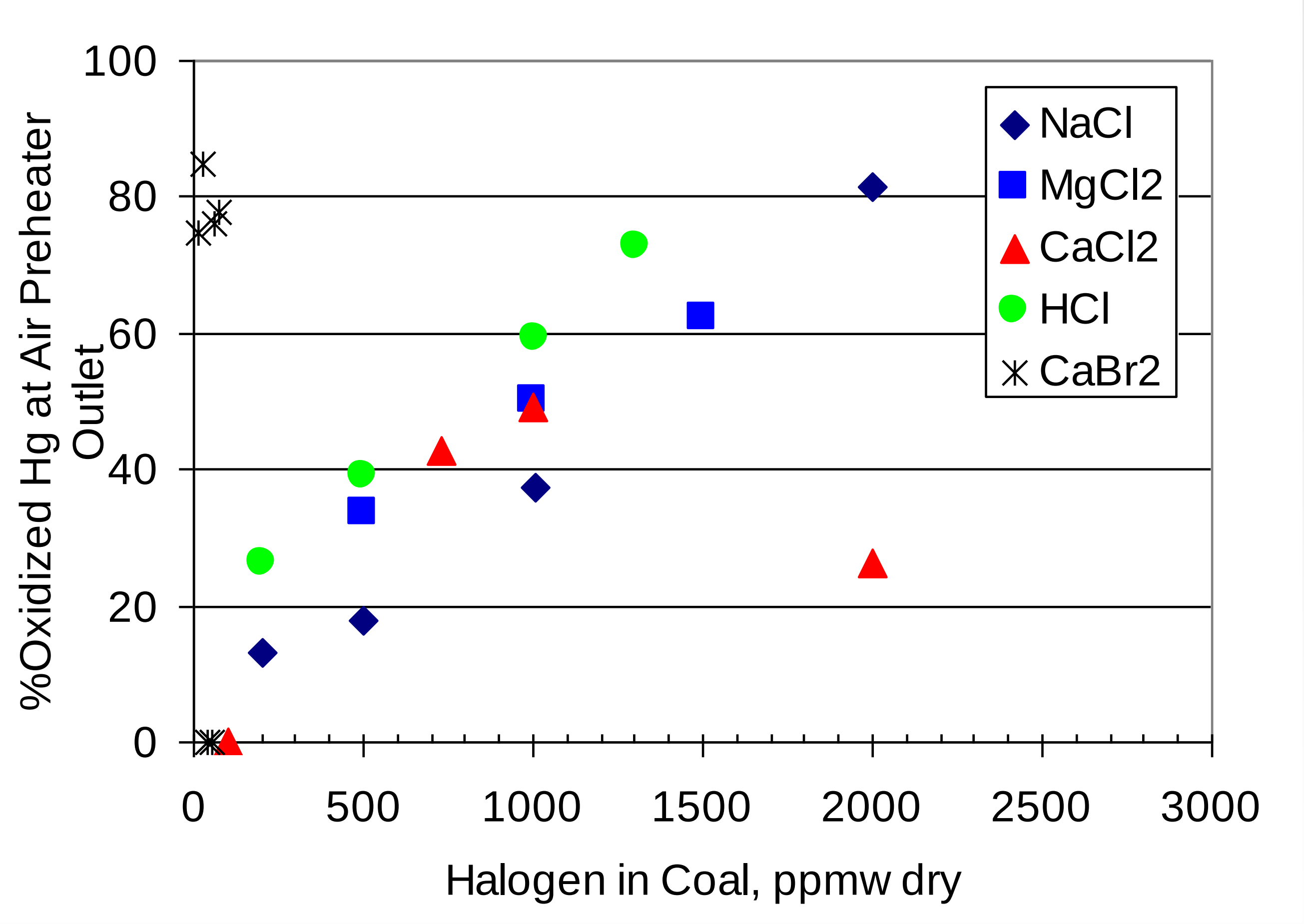
- Coal Type
  - Halogen content (Cl, Br, other)
  - Sulfur content
  - Mercury content
- Flue Gas
  - Acid Gases (HCl, SO_2, SO_3)
  - Gas Temperature **

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

** High flue gas temperature. may require addition of economizer/air heaters

Halogens Increase Oxidized Mercury

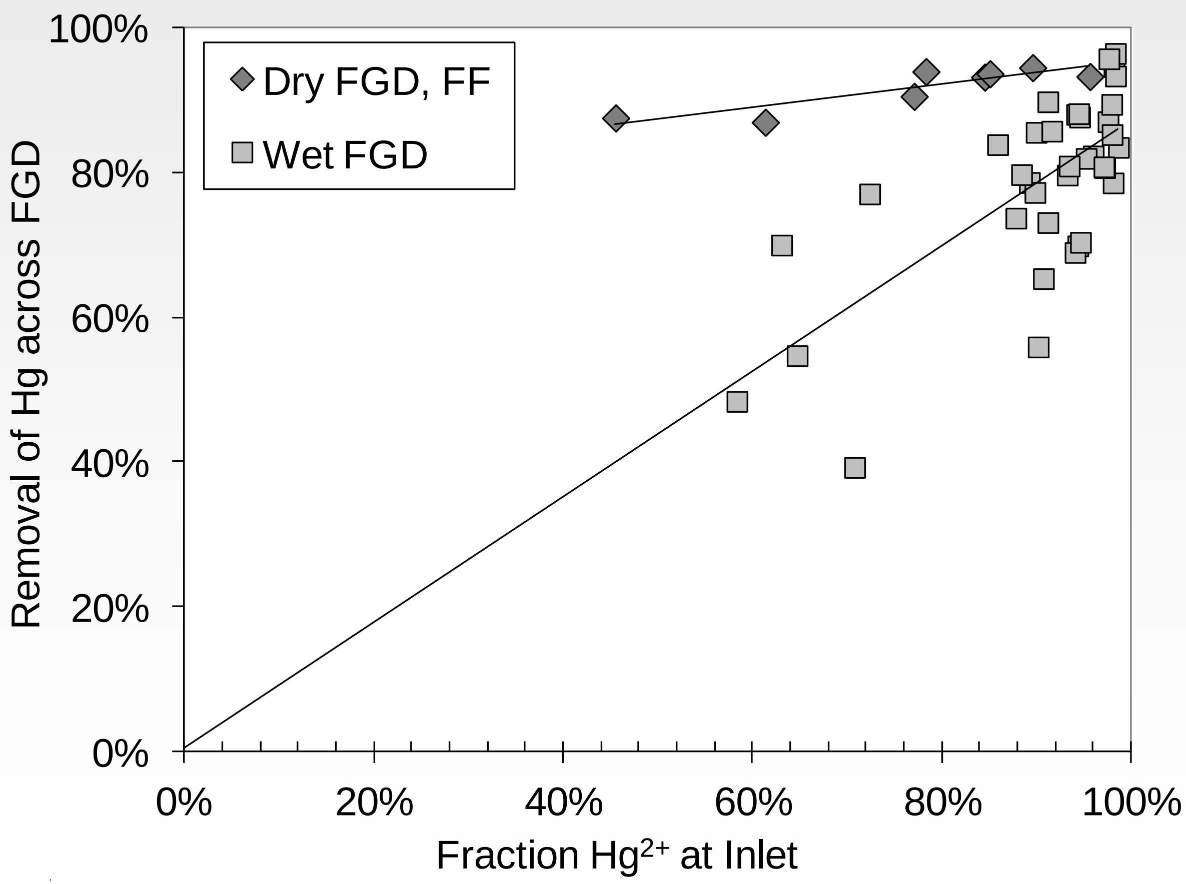


Halogen addition at various full-scale PRB boilers

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+})

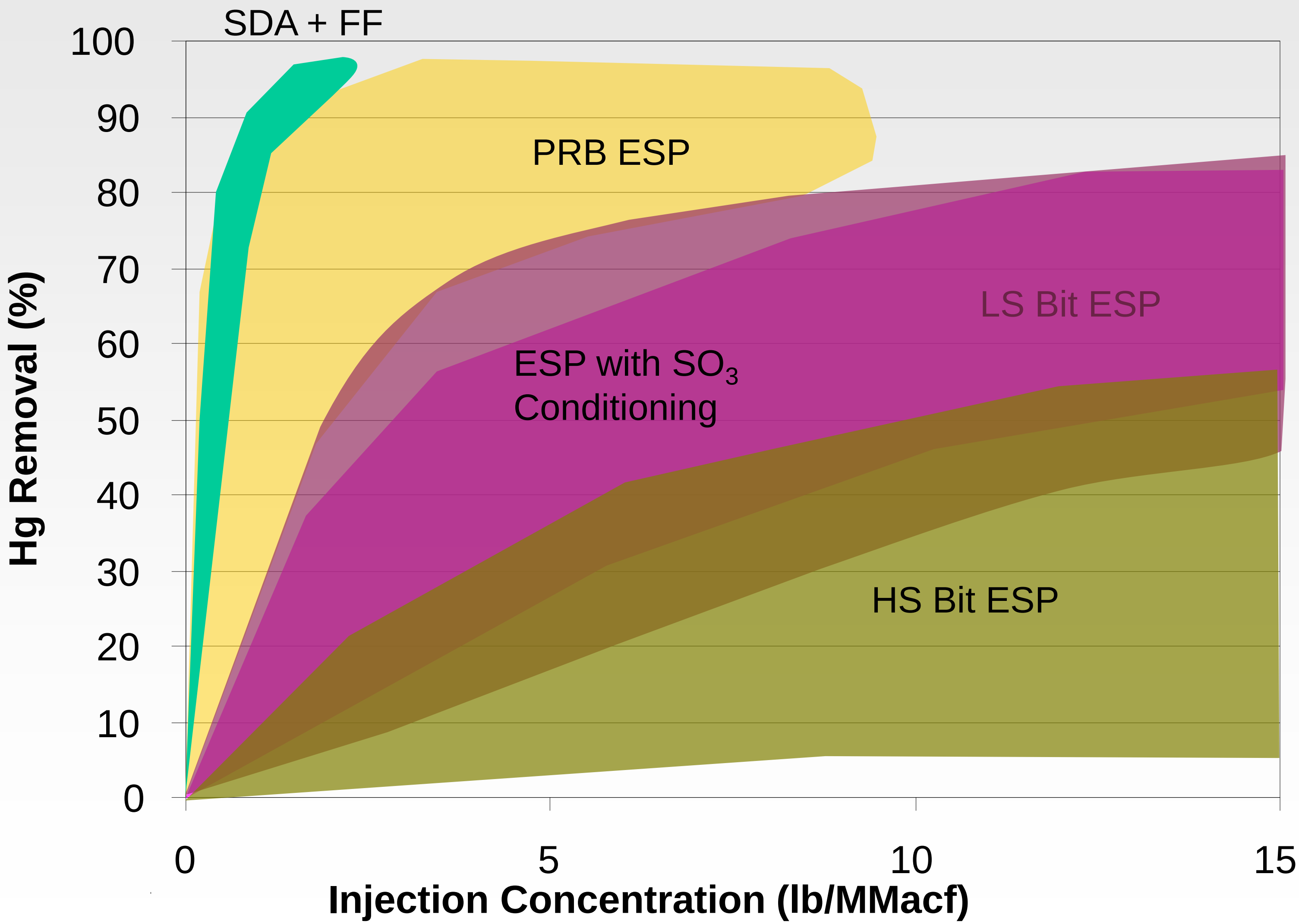


Activated Carbon Injection

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

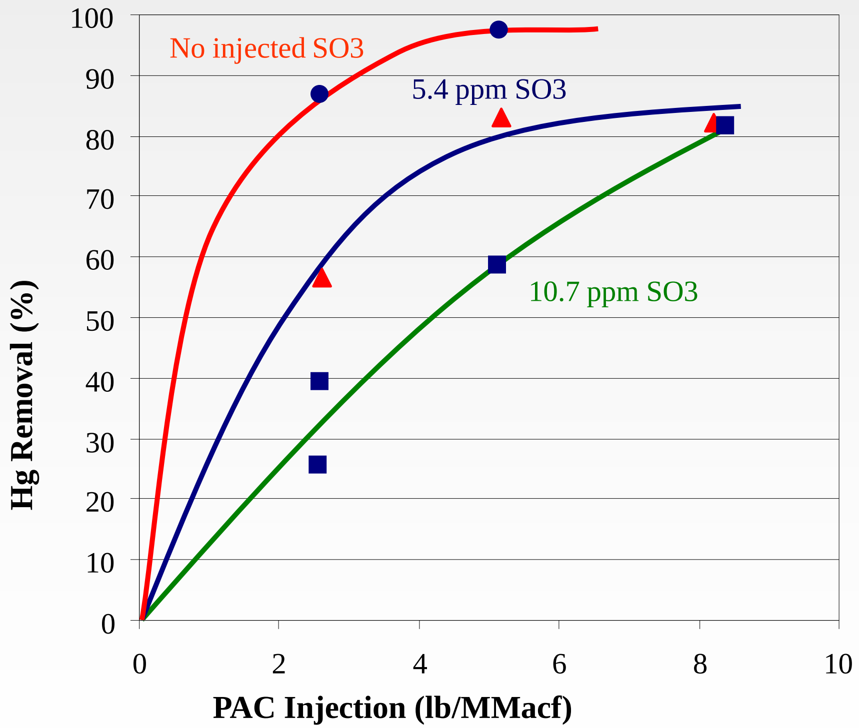
EPA Estimates 141 GW new ACI for utility boilers alone. Does not even count Industrial Boiler needs

Activated Carbon Injection Summary of PC Fired Utility Boiler Mercury Control Results

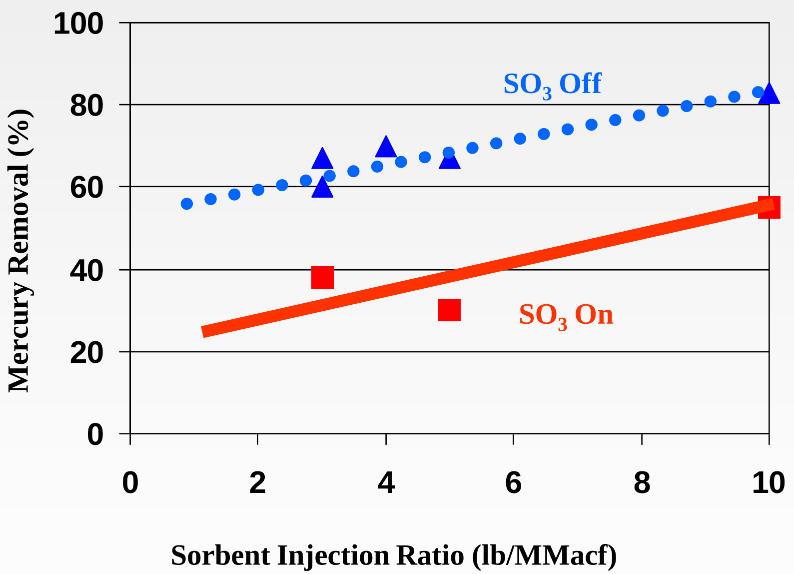


SO_3 Injection and PAC Effectiveness

- SO_3 is used to condition fly ash for better capture in ESPs
- Typical injection targets < 10ppm in gas phase
- Any SO_3 in gas phase appears to affect Hg capture



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



Mississippi Power Plant Daniel
Low sulfur bituminous coal

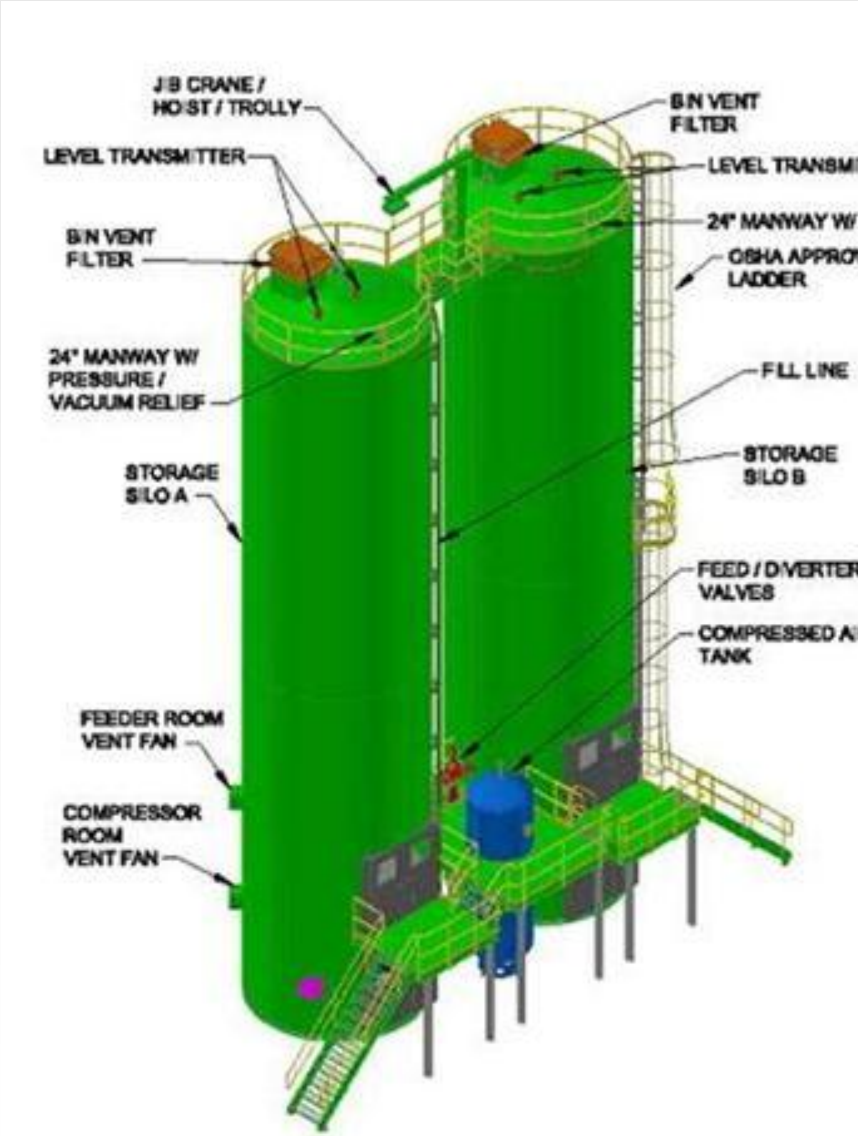
Compliance Strategies for HCl

- **Scrubbed Units** typically achieve sufficient HCl removal
- **Unscrubbed Units:**
  - Biomass: Wide range of coal chlorine, depending on biomass source; some control might be needed
  - Subbituminous-fired: Little or now control required to keep HCl below limit
  - Bituminous-fired: HCl limits may be difficult to achieve without FGD
  - *DSI may be used, depending on coal chlorine content*

Dry Sorbent Injection (DSI) Sorbents for Acid Gases (SO_2, HCl, SO_3)

- Different sorbents have been used for removal of acid gases:
  - Limestone
  - $Ca(OH)_2$
  - MgO, $Mg(OH)_2$
  - Trona (sodium sesquicarbonate), sodium bicarbonate, sodium bisulfite
- Considerations in choosing a specific sorbent
  - What needs to be removed?
  - Level of control needed?
  - Balance-of-plant impacts

DSI and HAPs Compliance



- Acid Gases (HCl):
  - ✓Alkali injection can be effective for HCl trim control
- Mercury (Hg):
  - ✓Alkali injection can effectively be used to protect AC by lowering SO_3
- PM:
  - Must consider potential impacts

Options for Total PM

- New fabric filter or ESP upgrade might be required
- Hot to Cold-Side ESP conversions (as needed)
- DSI + ACI + FF may be a viable option for to achieve combined HCl, Hg and PM controls (where coal sulfur and chlorine is limited)

Coal to Stack: Integrated Approaches for Multi-Pollutant Compliance

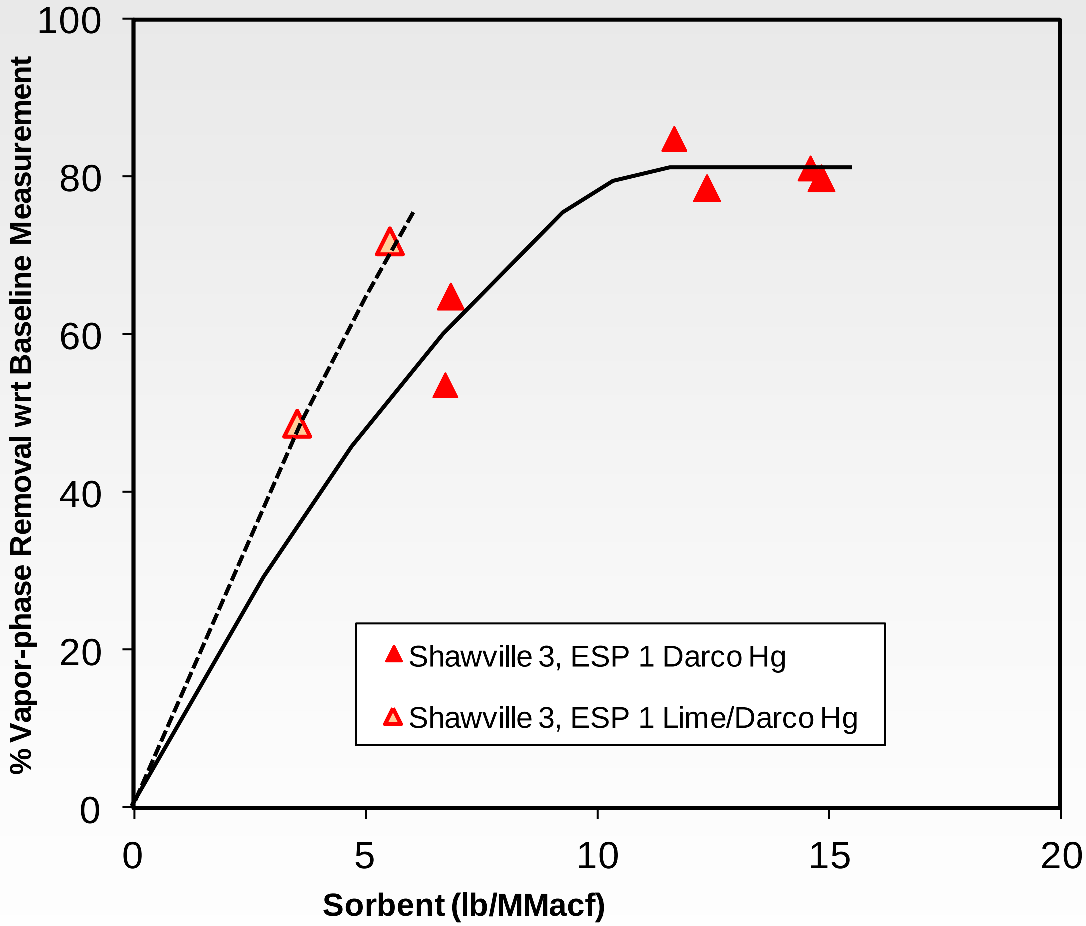
Examples:

- Fuel (low mercury, low sulfur, low chlorine)
- DSI as required to meet HCl limits and/or control SO_3 to maximize ACI effectiveness
- Utilize coal additives to manage ACI usage and Hg removal effectiveness

DSI-ACI Synergy: Example

Medium-sulfur bituminous plant

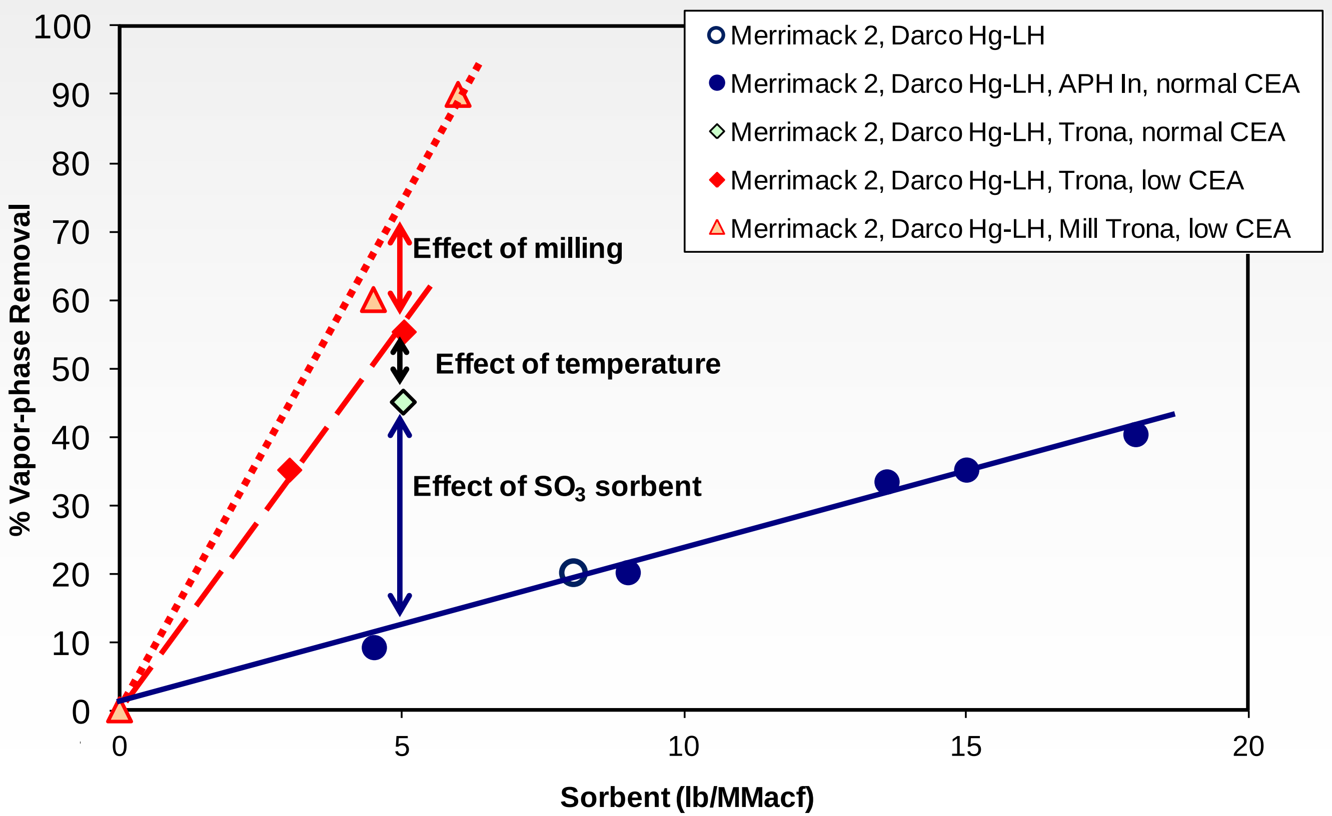
Lime injection to reduce SO_3 => improve ACI performance for Hg control



DSI-ACI Synergy: Example

Low-sulfur bituminous plant with SCR

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



Summary

- HCl
  - 0-90%% control required for coal-fired units – less reduction (if any) for biomass-fired units
  - Bituminous coals have higher chlorine and require higher reductions

- Mercury
  - 65-90%% control required for coal-fired units – less reduction (if any) for biomass-fired units
  - Achievable on most subbituminous and biomass units
  - Limits may be challenging on units with higher sulfur coals and may require SO_3 mitigation
- Total PM
  - May result in new fabric filters or hot- to cold-side ESP conversions

Creating a Future with Cleaner Coal

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