Air Pollution Compliance Strategies for Coal Generation

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EUCI

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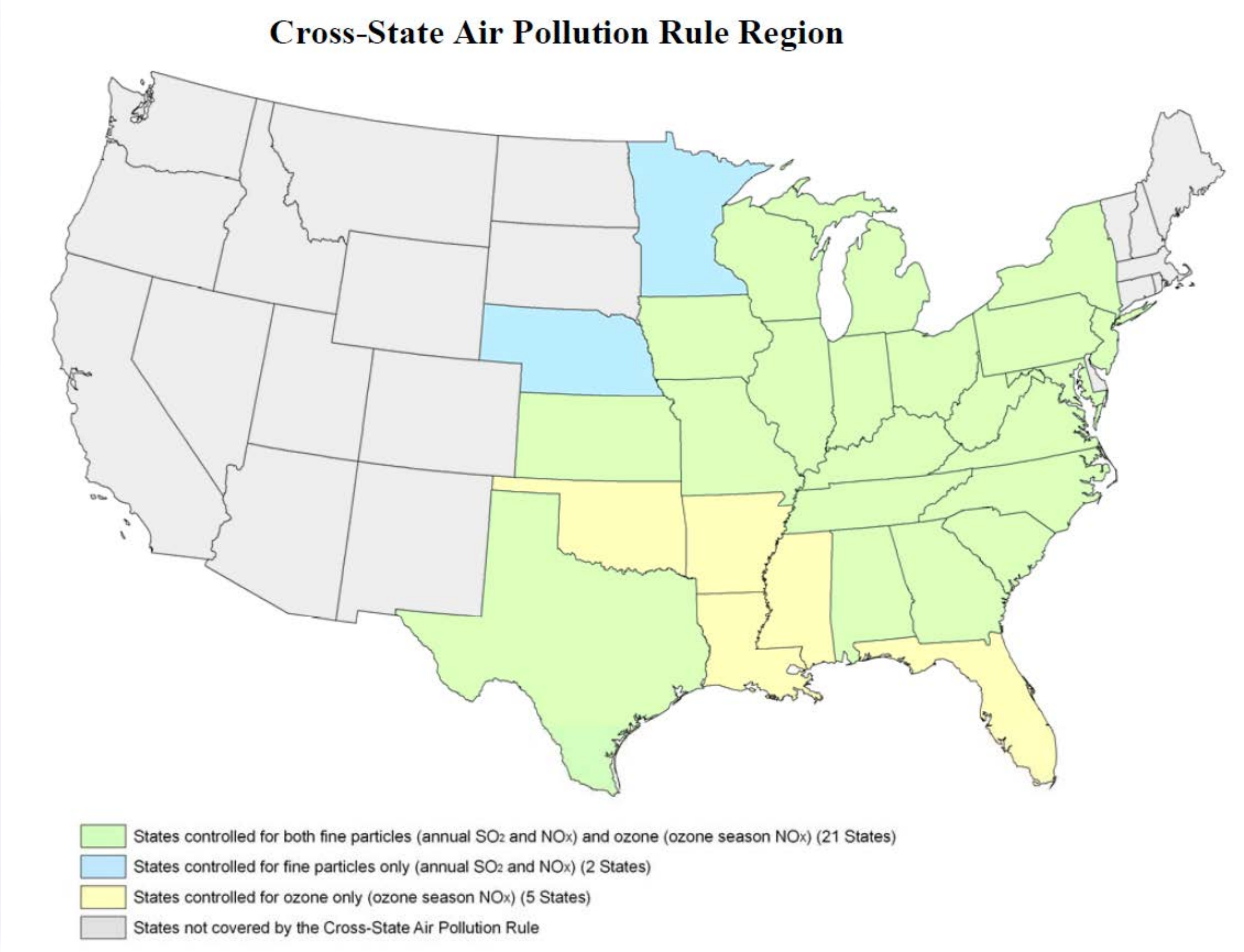
Two Rules of Interest

- Cross-State Air Pollution Rule (CSAPR)
  - Establishes NOx and SO2 standards for reducing
    - Fine PM
    - Ozone
- Mercury and Air Toxics Standards (MATS)
  - Establishes standards for Hg, PM and Acid Gases

Cross-State Air Pollution Rule



Cross-State Air Pollution Rule

- Establishes state budgets for NOx and SO_2
  - 2012 and 2014 budgets
  - Base budget plus allowance for variability
- EPA developed unit allocations that states can accept as a FIP, or they can modify by applying for a SIP
- Trading within a trading rule (TR) program is allowed
  - Intrastate trading unconstrained
  - Interstate trading constrained by budget plus variability limits

CSAPR Controls

– more of the same

- NOx and SO_2 controls, per SIP Call and CAIR
  - – But not in the same numbers – at least for scrubbers and SCR
    - Likely to see more SNCR
  - – Less focus on wet FGD, more on dry FGD
  - – Perhaps even some DSI
    - Many of these also driven by BART

Mercury and Air Toxics Standards (MATS)

- Mercury
- Total Particle Matter (PM)
  - Filterable PM
  - Condensable PM
- Acid Gases – mostly HCl
- 3 year compliance period
  - with case-by-case extensions up to 4 years

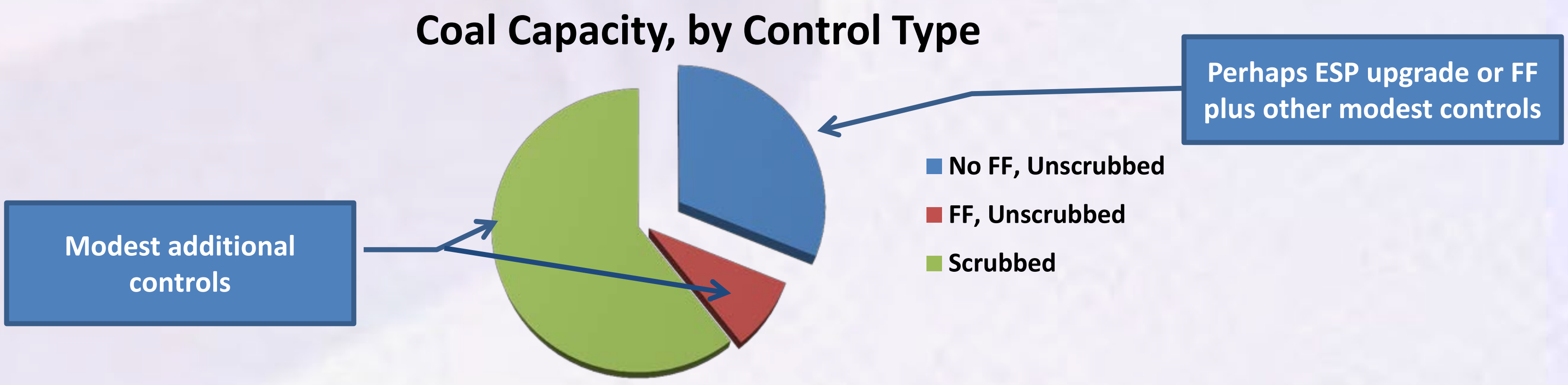
HAPs Pollutants and Controls

Control Technology Emission Reduction Effect					
	Mercury (Hg)	HCl	Total PM	Capital Cost $/kW	Time to install
Filterable PM Controls (ESP or Fabric Filter)	C	N	Y	<$100 (ESP upgrade) ~$150 (new FF)	<2 years
Low-Sulfur Fuel	N	C*	C*	-	-
Wet Scrubber	C	Y	C	~$500	3-4 years
Dry Scrubber	C	Y	C**	~$400	<3 years
Dry Sorbent Injection (DSI)	C	Y	Y	$10-$40	~1 year
Activated Carbon Injection (ACI)	Y	N	N	~$10	< 1 year
Bromine or chemical addition	Y	N	N	-	Months

N = Technology has little or no emission reduction effect
Y = Technology reduces emissions
C = Technology is normally used for other pollutants, but has a co-benefit emission reduction effect
* Low sulfur fuel, especially Powder River Basin (PRB) coal, tends to result in low HCl and low condensable PM emissions. PRB fuel is naturally low in chlorine and its ash is high in calcium, which absorbs HCl and total PM precursors
** Especially when used in combination with a downstream particle matter control device, such as a baghouse

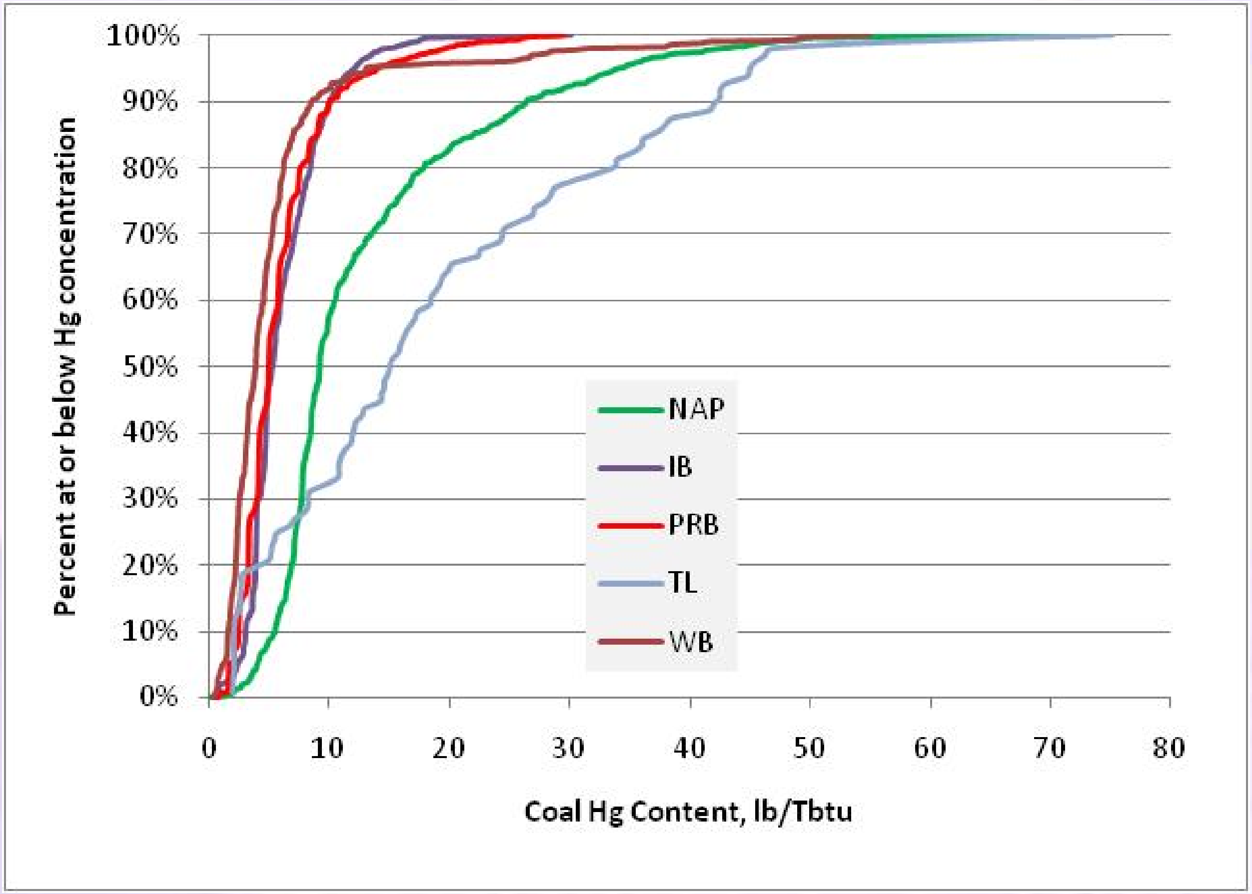
Current Industry Situation with MATS

- Thanks to CAIR, most coal capacity is already scrubbed
  - Additional controls, if at all, will be modest for scrubbed units or units with fabric filters (FF)
- Unscrubbed units have relatively low cost options
  - No need to add scrubbers for Air Toxics Rule



Data source: US EPA

Hg Concentrations



Hg concentrations vary widely by coal type and within coal types

Scrubbed Units

- For filterable PM – ESP upgrades
  - *Cond. PM – DSI, if needed (more on this later)*
- Likely in good shape for acid gas (ie., HCl)
- May or may not achieve 90% or more Hg removal without "help"
  - *Bromide or other additives*
- Depending upon coal, 90% Hg removal
  - may not be necessary, or
  - may not be enough

Options for Unscrubbed Units

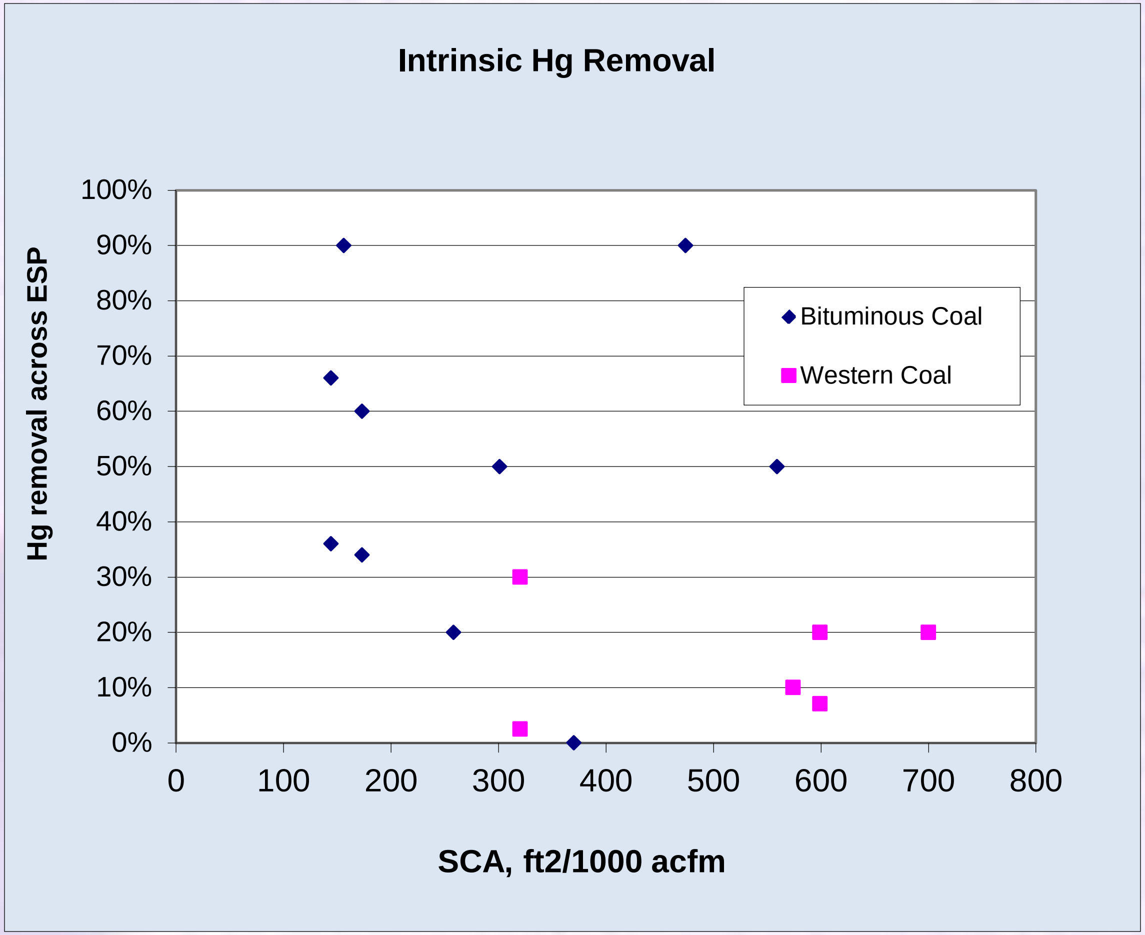
Will a fabric filter be necessary?

- For filterable PM – ESP upgrades, FF conversions, or polishing baghouse
  - *Cond. PM – DSI, if needed (more on this later)*
- For Hg – Activated Carbon and/or Halogen Addition with *possible* need for FF
- For HCl, if needed - Dry Sorbent Injection
  - Trona, Sodium Bicarbonate, or Activated Lime Hydrate

ESP Testing a Myth - Does Size Really Matter?

- Some have suggested that ESP size has an impact on Hg removal by ACI
- ACI has been postulated to be contributor to higher PM emissions
  - even a trigger for PSD!
- Took a look at data to see any trends

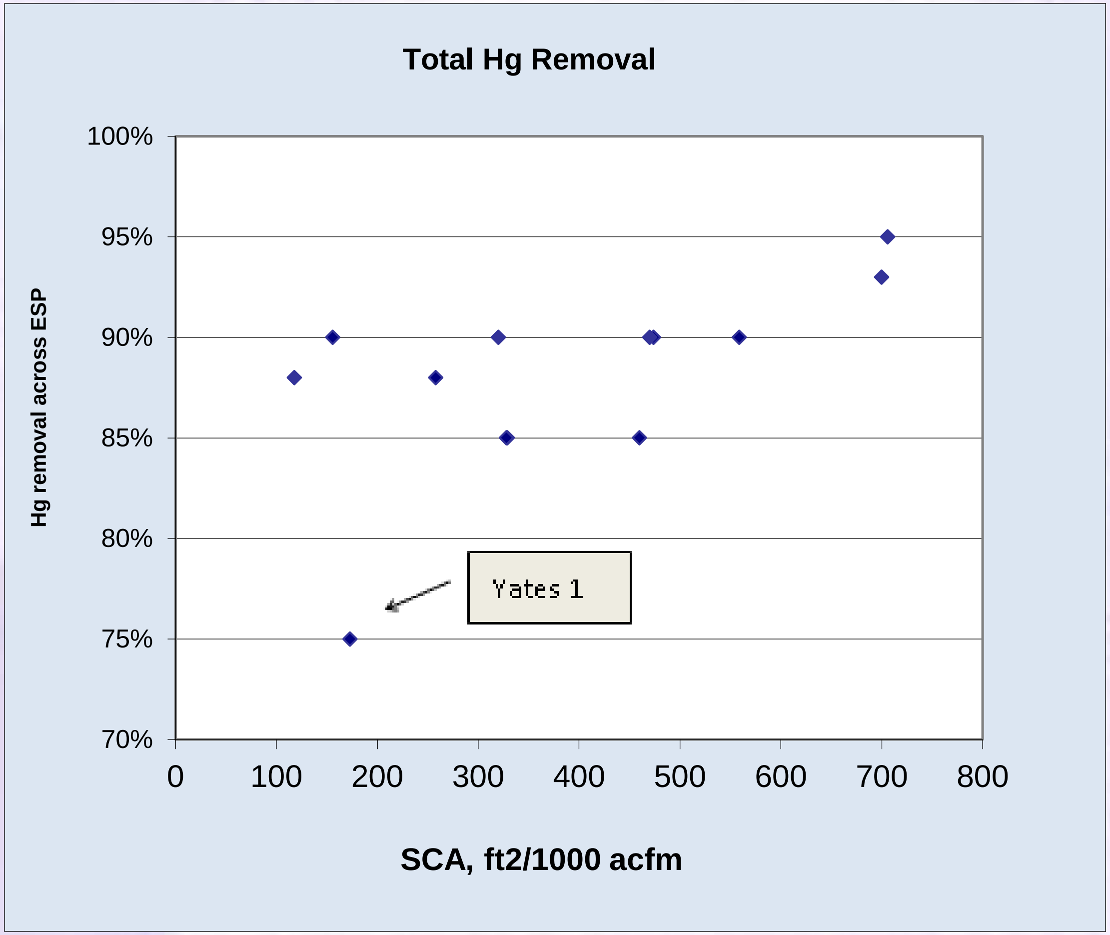
Intrinsic Hg Removal versus ESP Size



No real trends, except that Bituminous has higher intrinsic removal than western coal.

Staudt, J., “Does ESP Size Really Matter?, www.AndoverTechnology.com

ACI Hg Removal versus ESP Size

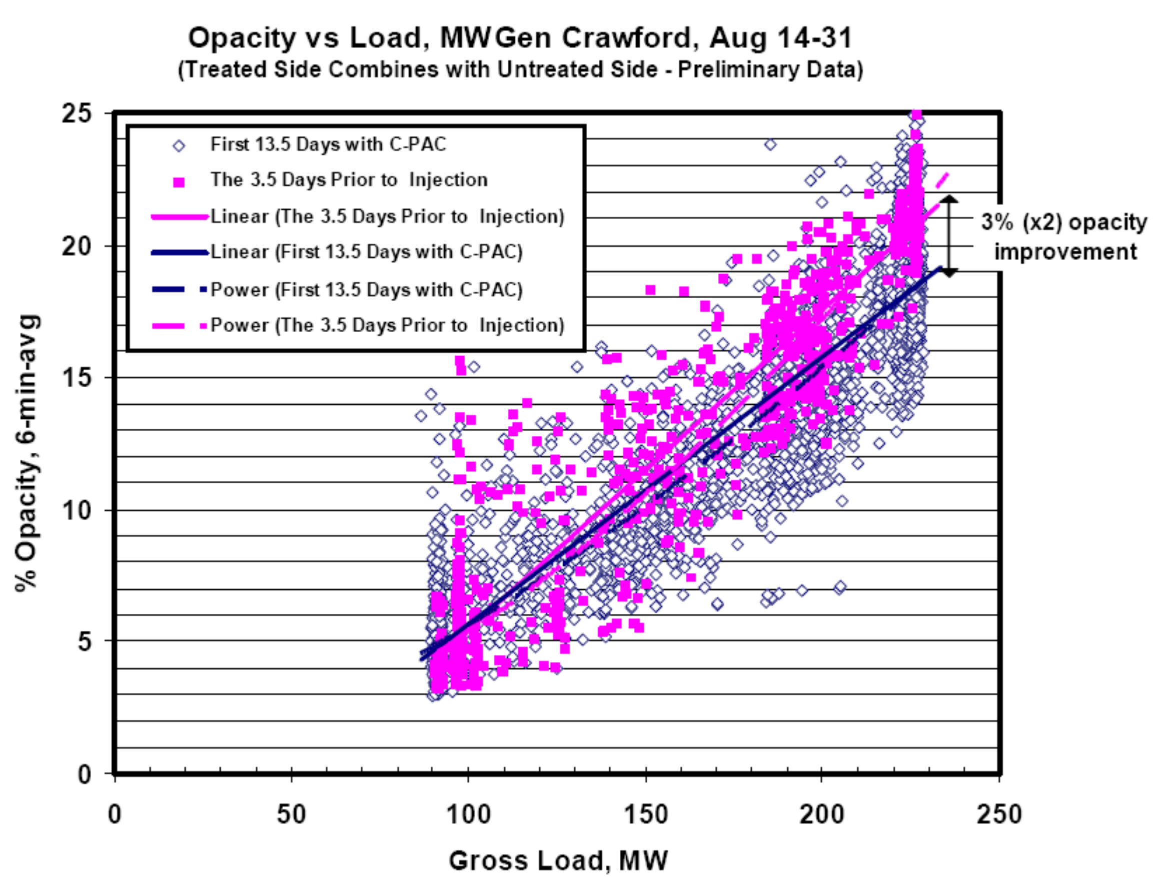


Hg capture doesn't seem impacted by ESP size without SO_3 conditioning.

CFD modeling showed poor AC distribution in duct at Yates.

Staudt, J., "Does ESP Size Really Matter?, www.AndoverTechnology.com

Impact of ACI on Opacity



ACI doesn't have impact on opacity for ESP with SCA of only 118.

No facilities have triggered PSD from installation of ACI.

From **DOE NETL Project DE-FC26-05NT42308 and discussed in** Staudt, J., "Does ESP Size Really Matter?, www.AndoverTechnology.com

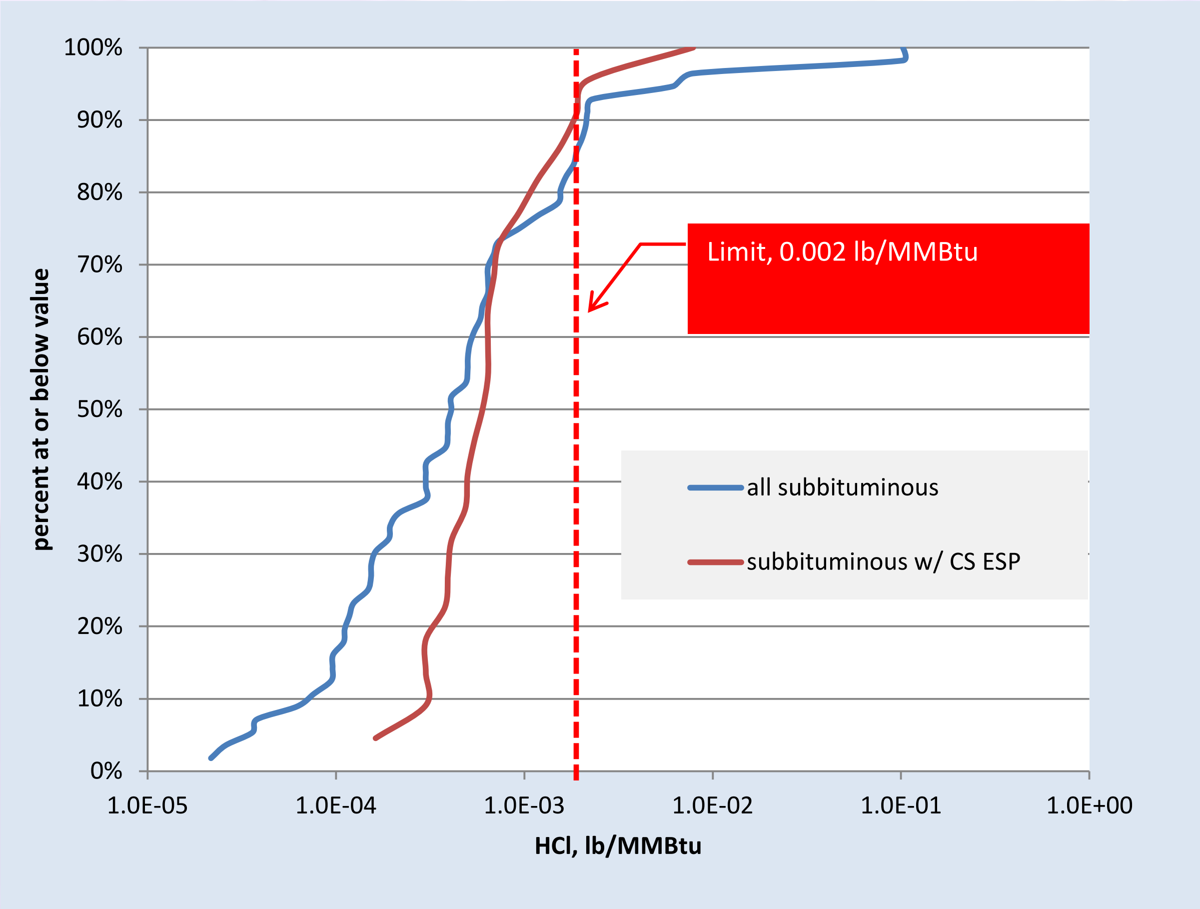
Effect of ESP Size/ACI Effect on PM Emissions

- No Impact on Hg removal from ESP Size
  - *Except when it is the reason why SO3 flue gas conditioning is used; however, there are alternatives to SO3 conditioning*
- ACI impact on PM emissions is much less than anticipated
  - Very small contribution to total PM into ESP
  - ESP behaves more like a constant PM emissions device than a constant percent reduction device
    - Outlet emissions not as sensitive to inlet PM loading as you might think

EPA's FF and DSI projections

- EPA's original projection of FF retrofits is too high
  - Doesn't adequately consider ESP upgrades
  - Conservative assumptions about Hg control
- EPA's original projection of DSI retrofits is too high
  - PRB coal has inherently low HCl and condensable PM emissions – little or no need for DSI on PRB coal units

HCl – Subbituminous Coal



Most Subbituminous units expected to meet HCl limit without any additional controls.

Very little DSI needed for PRB Units.

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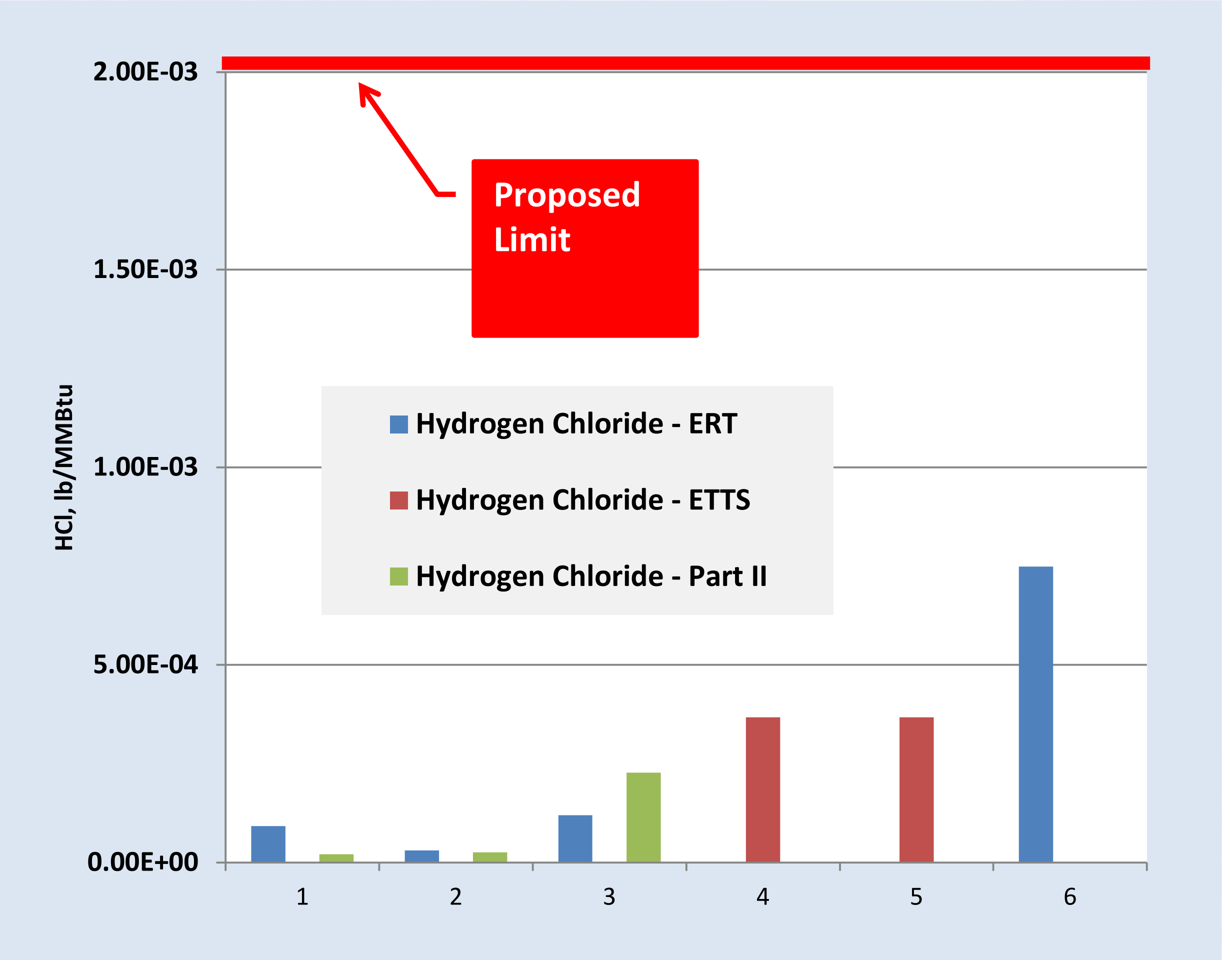
Acid Gas –Texas Lignite Coal



Acid gas emissions from TX lignite were well below limit, no doubt from high concentration of alkaline fly ash .

Very little DSI needed for lignite.

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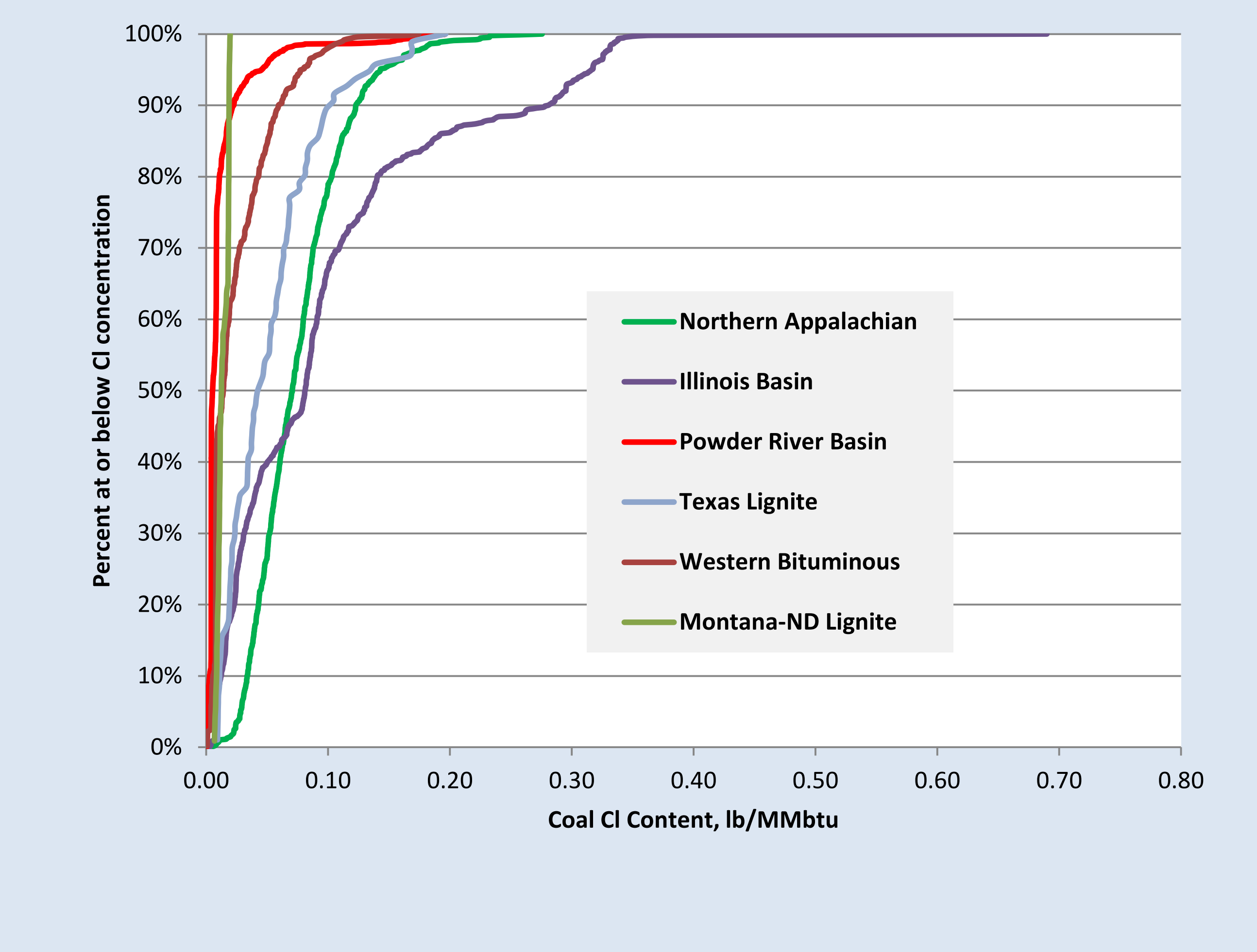
Coal Chlorine Content



Few units firing PRB coals will need HCl controls.

Lignite units not expected to require HCl controls.

Unscrubbed units burning Northern Appalachian and Illinois Basin coals are the most likely to need additional controls for HCl, such as DSI.

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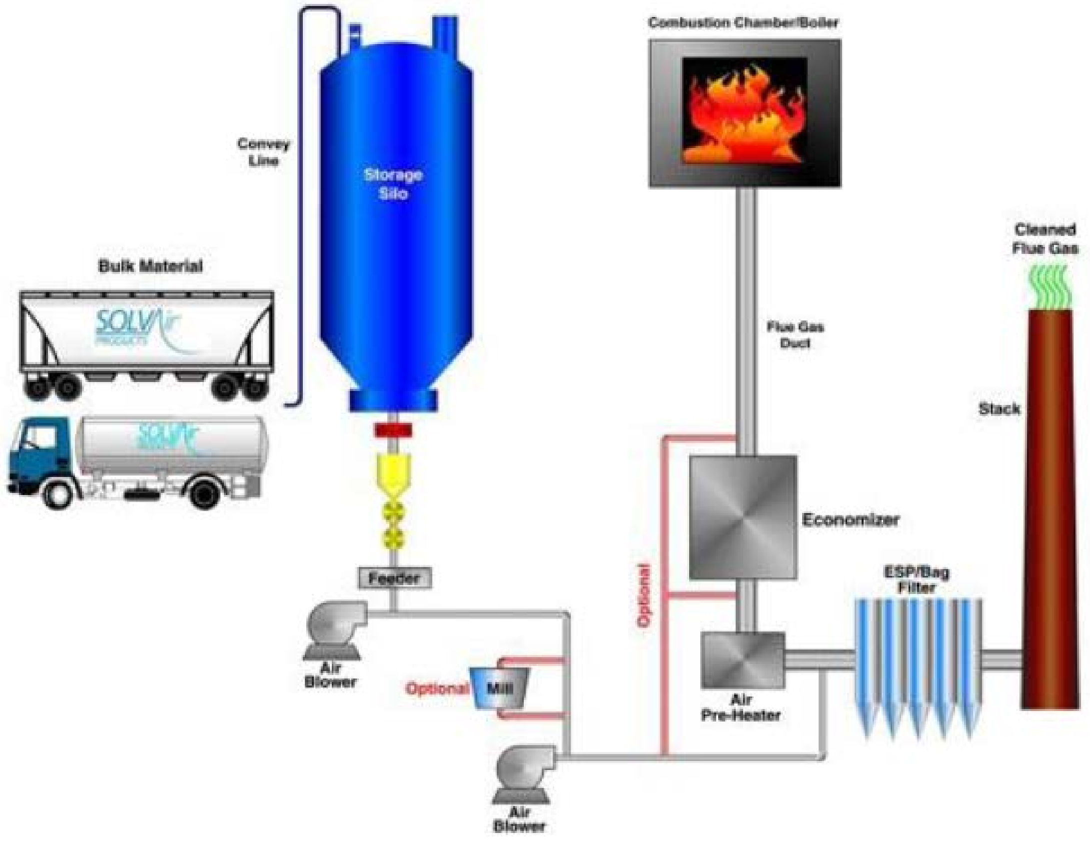
Dry Sorbent Injection



Source: Solvair

- Decades of experience
- Currently in coal units as large as 1300 MW for SO3 control
- Control of SO3, HCl, SO2
- Choice of reagent depends on application: Trona, SBC, lime, SBS
- Trona and SBC most commonly used

Is DSI Limited to 300 MW Units for HCl or SO2 control?

- This is an assumption used in a few forecasts of compliance costs and retirements.
- No basis for this. Dominion is planning on DSI at the two 660 MW Kincaid units in Illinois.
  - BART study and application in 2009
  - Permit to construct issued in 2011
    - 0.20 lb/MMBtu limit in 2014
    - 0.15 lb/MMBtu limit in 2017

ENSR Corporation for Dominion, "BART Analysis for the Kincaid Power Plant", Document No.: 02285-076-400,   January 2009
Memorandum of Understanding, with cover letter from Pamela Faggert (Dominion) to James Ross (IEPA), dated February 3, 2009
Construction Permit, Application No.: 09080047, I.D. No.: 021814AAB, , Subject: Pilot Evaluation of Sorbent Injection for SO2 Control for Unit 1 or 2, Date Received: April 22, 2011, Date Issued: June 9, 2011
Joint Construction and Operating Permit, Application No. 09050022, ID No. 021814AAB, Subject: Control Program for Mitigation of Visibility Impairment, Date Received: May 6, 2009, Date issued: June 24, 2011.

HCl and HF removal at Mirant Potomac Station

Removal of HCl and HF

	Trona Injection	SBC Injection
HCl (%)	98.8	97.8
HF (%)	78.4	88.0

Kong, Y., et al, “Dry Sorbent Injection of Sodium Bicarbonate for SO2 Mitigation”, Power Gen 2008

Hg Removal At Constellation Wagner 2

	No Trona No PAC	With Trona No PAC
SO_3 @ APH Inlet (ppm)	6.8	5.4
SO_3 @ Stack (ppm)	4.9	0
Mercury Reduction Rate* (%)	82%	90%

* Native Hg removal by air heater and ESP

- Data from Unit 2
- The amount of trona injected (NSR=1.1) removed 29% of SO_2

Kong, Y., et al, "Dry Sorbent Injection of Trona and Sodium Bicarbonate for SO2, SO3, NOx and Mercury Mitigation", Power Gen 2009

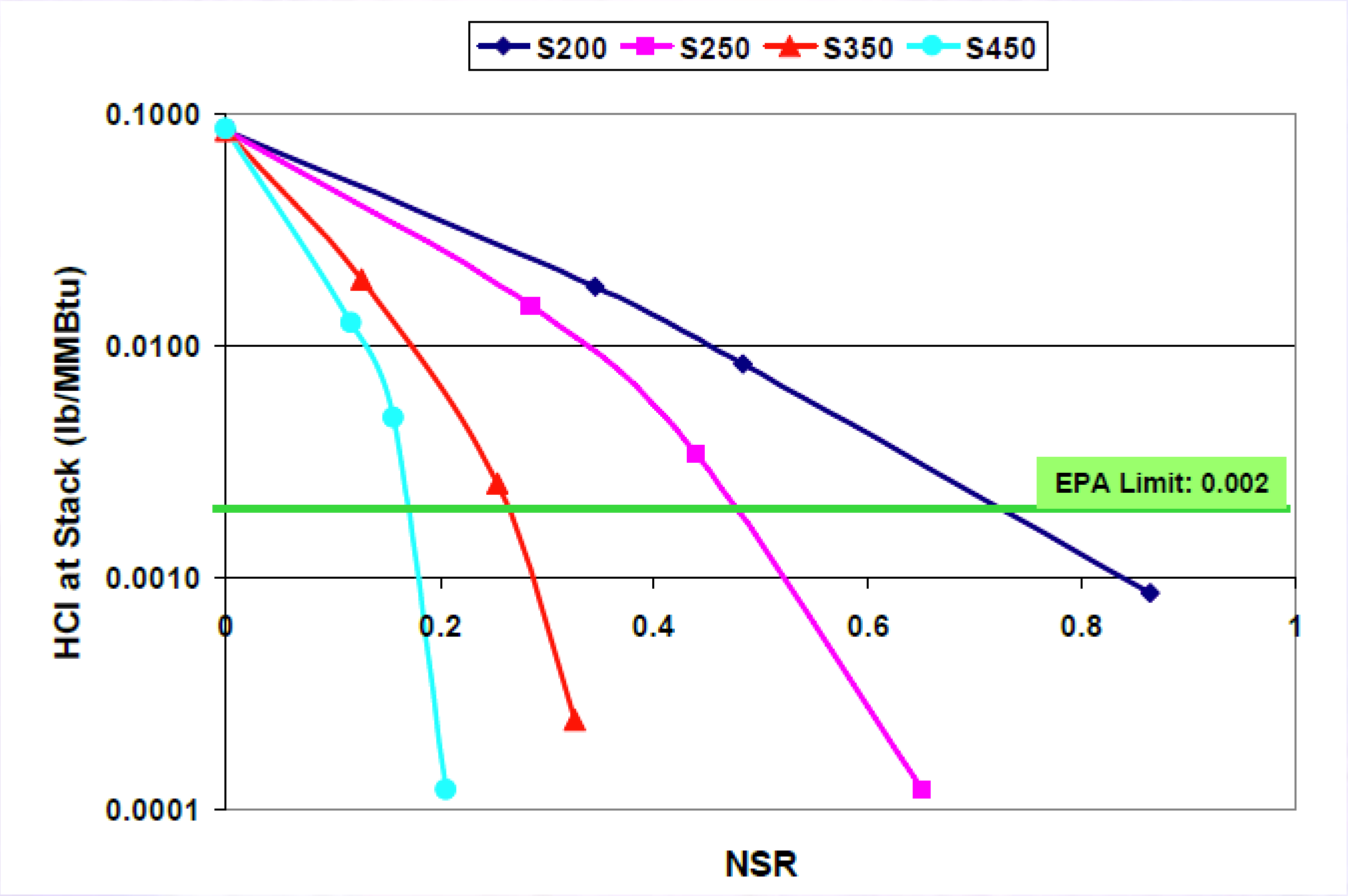
PM Emissions At Constellation Wagner 2

	Baseline (No Trona)	With Trona (NSR=1.1 based on SO_2)	PM Reduction Rate
Filterable PM (g/dscf)	0.088	0.0045	95%
Condensable PM (g/dscf)	0.0288	0.01424	51%
Total PM (g/dscf)	0.1209	0.0276	77%

- Data from Unit 2
- No PAC injection
- The amount of trona injected (NSR=1.1) removed 29% of SO_2

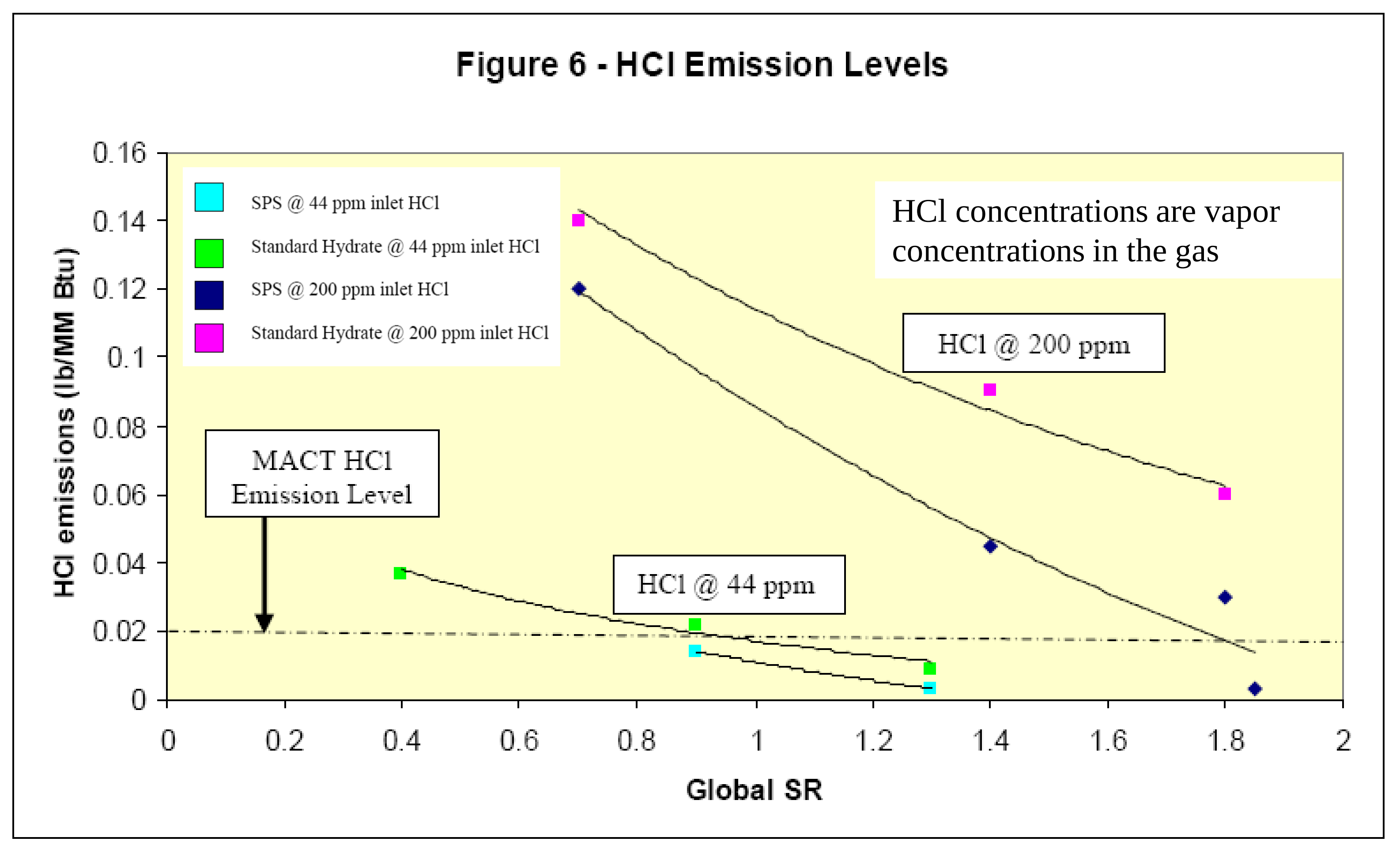
Kong, Y., et al, "Dry Sorbent Injection of Trona and Sodium Bicarbonate for SO2, SO3, NOx and Mercury Mitigation", Power Gen 2009

DSI – Central App. Coal Pilot Tests (ESP)



Yougen Kong, Ph.D., P.E., , “Dry Injection of Trona and Sodium Bicarbonate for Multi-Emissions Control”, Solvay Chemicals, Inc., McIlvaine Company Hot Topic Hour on, “Multi-Emissions Control”
October 27, 2011

Pilot Tests – Activated Lime Hydrate



Dickerman, J., Gambin, A., "Low Capital Cost Acid Gas Emission Control Approach", Mega Symposium (Poster Session), 2010

Considerations with DSI

- Impact on PM control
  - Trona or SBC *improves* ESP performance
- Incremental NOx removal with Trona/SBC
  - Some conversion to NO_2
- Disposal of by-product
  - May be a concern for trona or SBC
- Impact on Hg capture
  - Beneficial for bituminous coals
  - Possibly adverse for PRB coals at high treatment

Thank You!

- For Questions or Comments
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