

Worldwide Pollution Control Association

WPCA-Duke Energy

Is Your Precipitator Ready for MATS?

Aug. 28, 2012 – Plainfield

Sept. 11, 2012 - Charlotte

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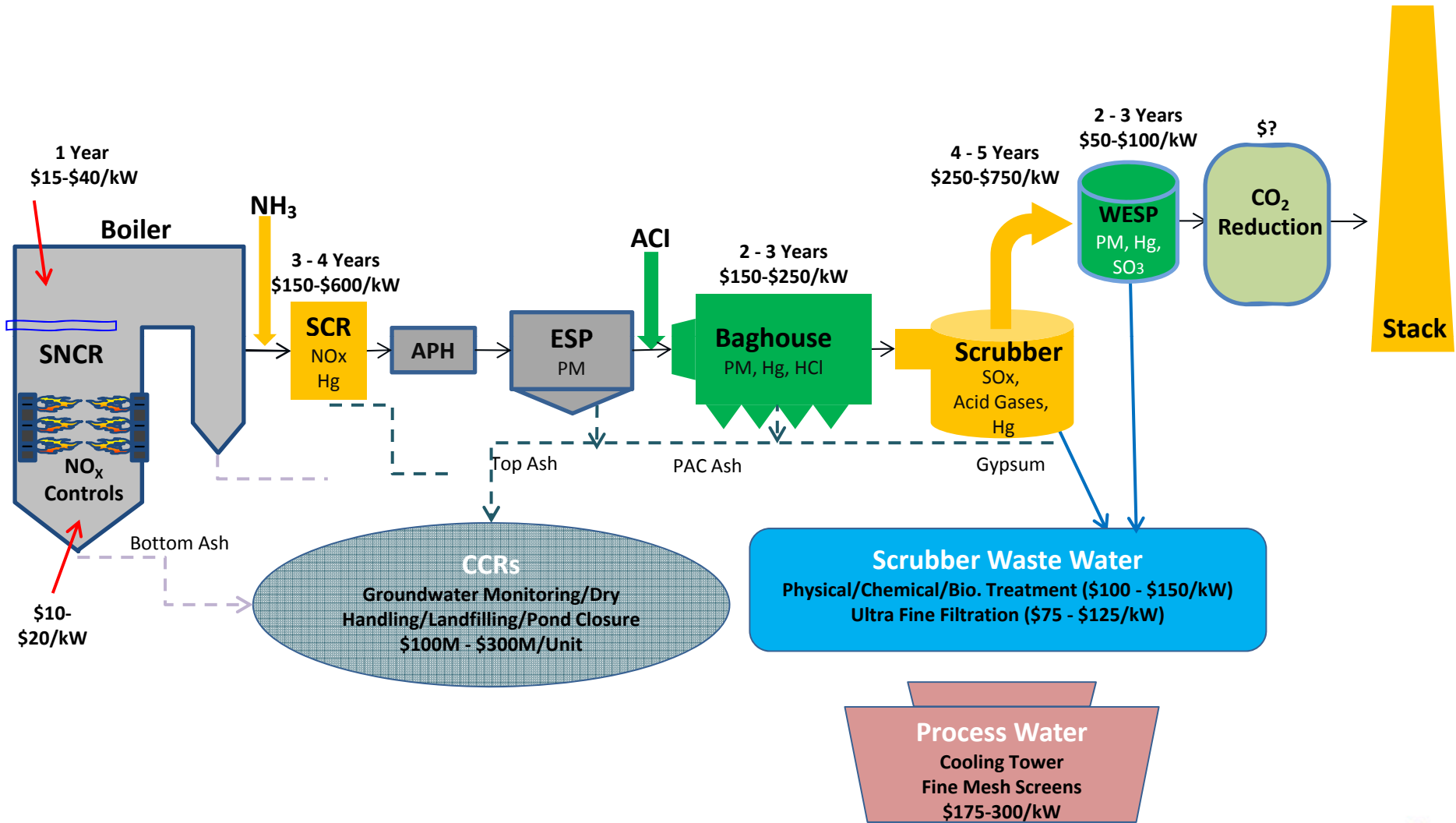
Mercury Basics

Mark S. Berry, PE

Research & Technology Management



A "Controlled" Future



Mercury & Air Toxics (MATS) Limits

Emission Standards for Existing Coal-Fired Power Plants

Pollutant	Input Base Limit	Output Based Limit
Mercury	1.2 lb x 10¹² (TBtu)	0.013 lb / GWhr
Filterable PM	0.03 lb x 10 ⁶ Btu (MMBtu)	0.30 lb / MWhr
HCl / SO ₂	0.002 x 10 ⁶ Btu or 0.2 x 10 ⁶ Btu (MMBtu)	0.02 lb / MWhr or 1.5 lb / MWhr

Emission Standards for New Coal-Fired Power Plants

Pollutant	Boilers
Mercury	0.0002 lb / GWhr
Filterable PM	0.0070 lb / MWhr
HCl / SO ₂	0.40 lb / GWhr or 0.4 lb / GWhr

Southern Company Mercury R&D Activities

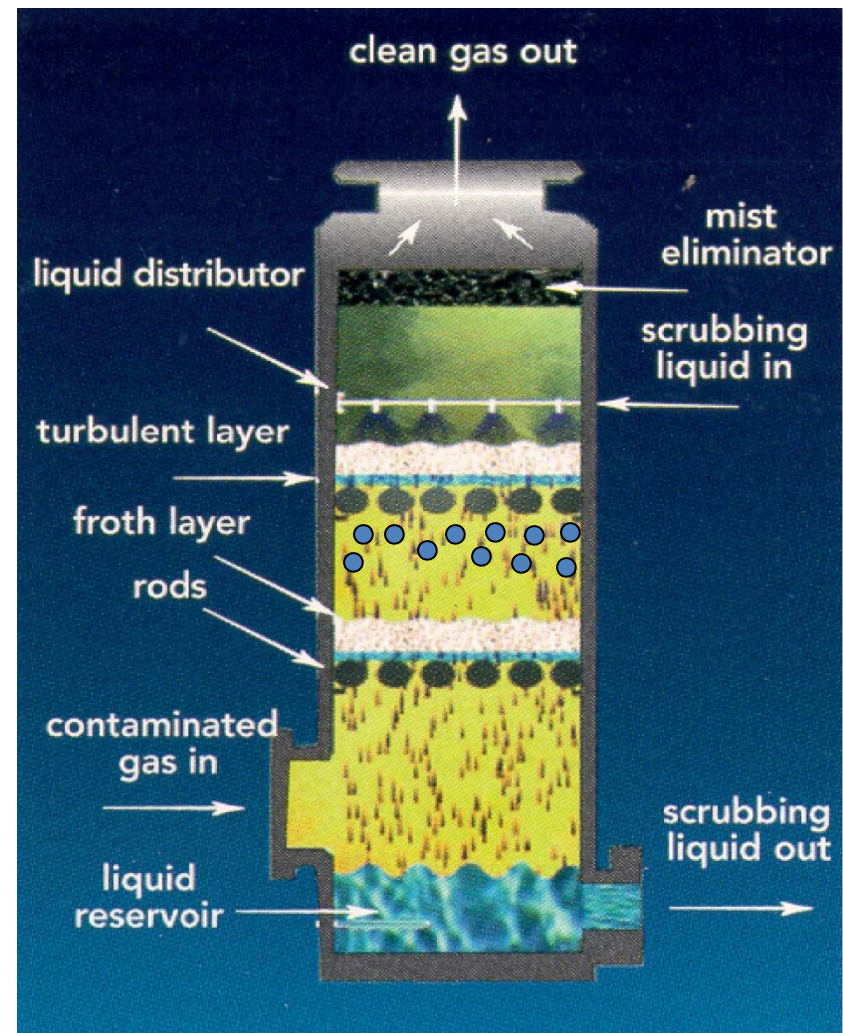
Major Insights

- Bromine improves Hg oxidation & activated carbon performance
- SO₃ impacts activated carbon Hg removal performance
- Hg removal & oxidation is a function of temperature
- Fabric filter dust cake make-up is vital to ACI ultimate performance
- Co-benefit and carbon approaches are the only viable candidates for commercial use

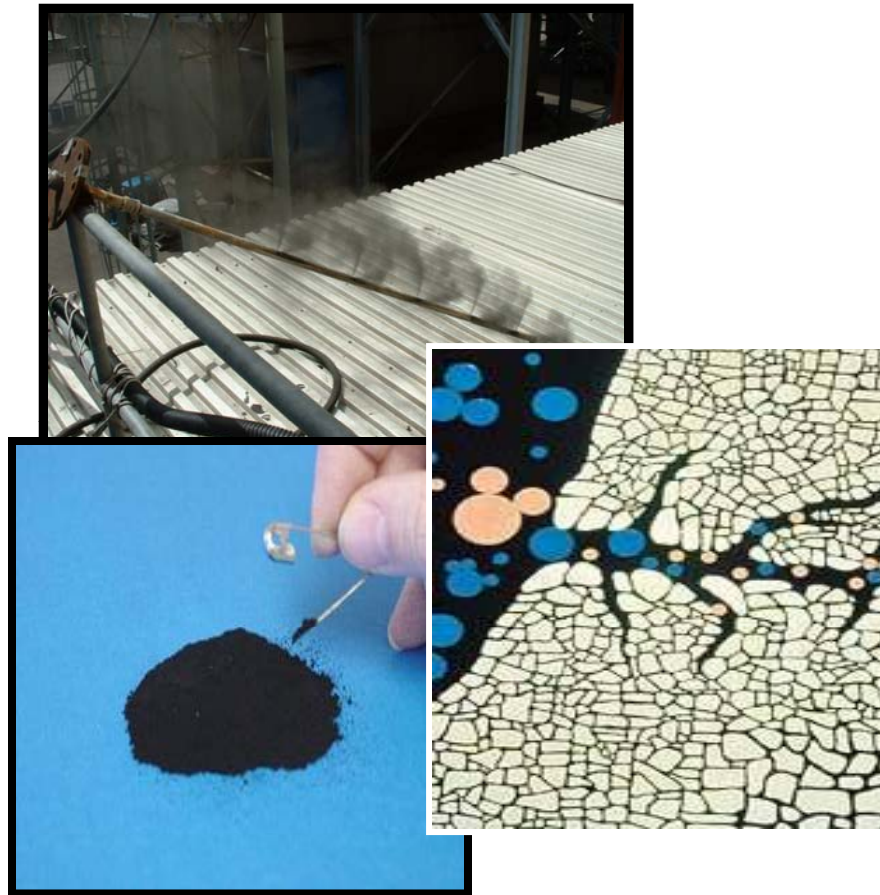
2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011-
Full Scale ACI into Baghouse On Bituminous Fuel	PEESP Plasma Enhanced ESP ElectroCore Spray Dryer Sodium Tetra Sulfide (Na ₂ S ₄)	MERCAP At Pilot & Full Scale ACI On Sub-Bituminous In Pilot FF	Small SCA ESP ACI on Bituminous Fuel	Large SCA ESP ACI on Bituminous Fuel Large SCA ESP ACI on Lower Sulfur Bituminous Fuel	Mercury Research Center Operational Bromine Sub-Bituminous Phase I Hg Oxidation / FGD Removal Pilot Scale Investigation	Bromine Bituminous Phase I High Dust SCR Hg Oxidation Study Scrubber Additives ESFF ACI Evaluation	Bromine Sub-Bituminous Phase II Fixed Structures ORP Hg Re-Emissions Four (4) Catalyst Type Hg Oxidation Evaluation	Bromine Bituminous Phase II MercScreen NH ₄ Cl Oxidation At Pilot Scale	TRAC Oxidation Testing Large Scale Bromine Bituminous Bromine Sub-Bituminous Phase III	NH ₄ Cl Oxidation At Full Scale 5MW HS Demo at Plant Bowen Wansley HS ACI Demo Wansley Scrubber Additives Demo
Selected Projects										

Hg Control Basics

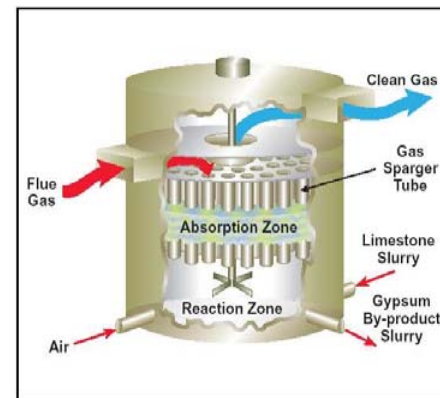
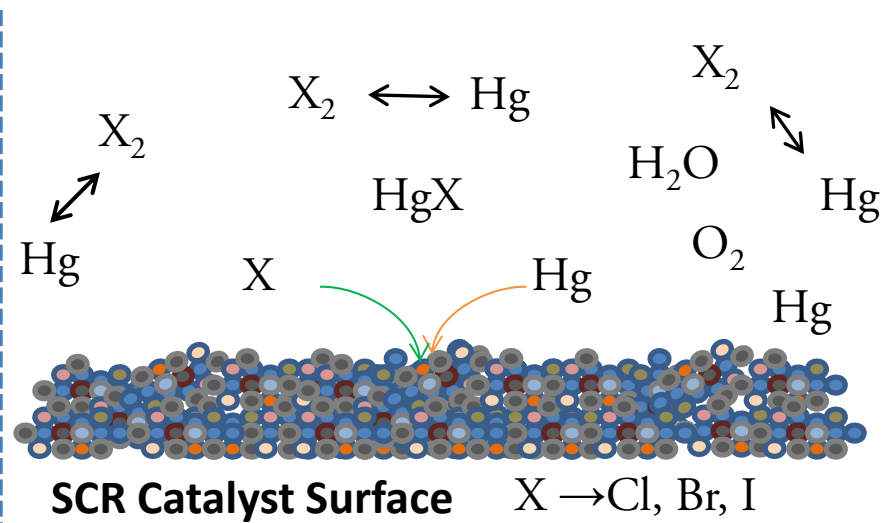
- Three forms of mercury:
elemental, oxidized &
particulate
- Percentage depends on flue
gas constituents'
- **Oxidized Hg (soluble)**
 - caught in WFGD with SO_2
- **Elemental Hg (insoluble)**
 - not captured in WFGD
 - other means of capture
- **Particulate Hg (1% - 2%)**
 - captured in ESP / FGD



Mercury Specific Technologies



Adsorption Approaches
(Solid)



Absorption Approaches
(Liquid)

Adsorption: Background

Typical properties:

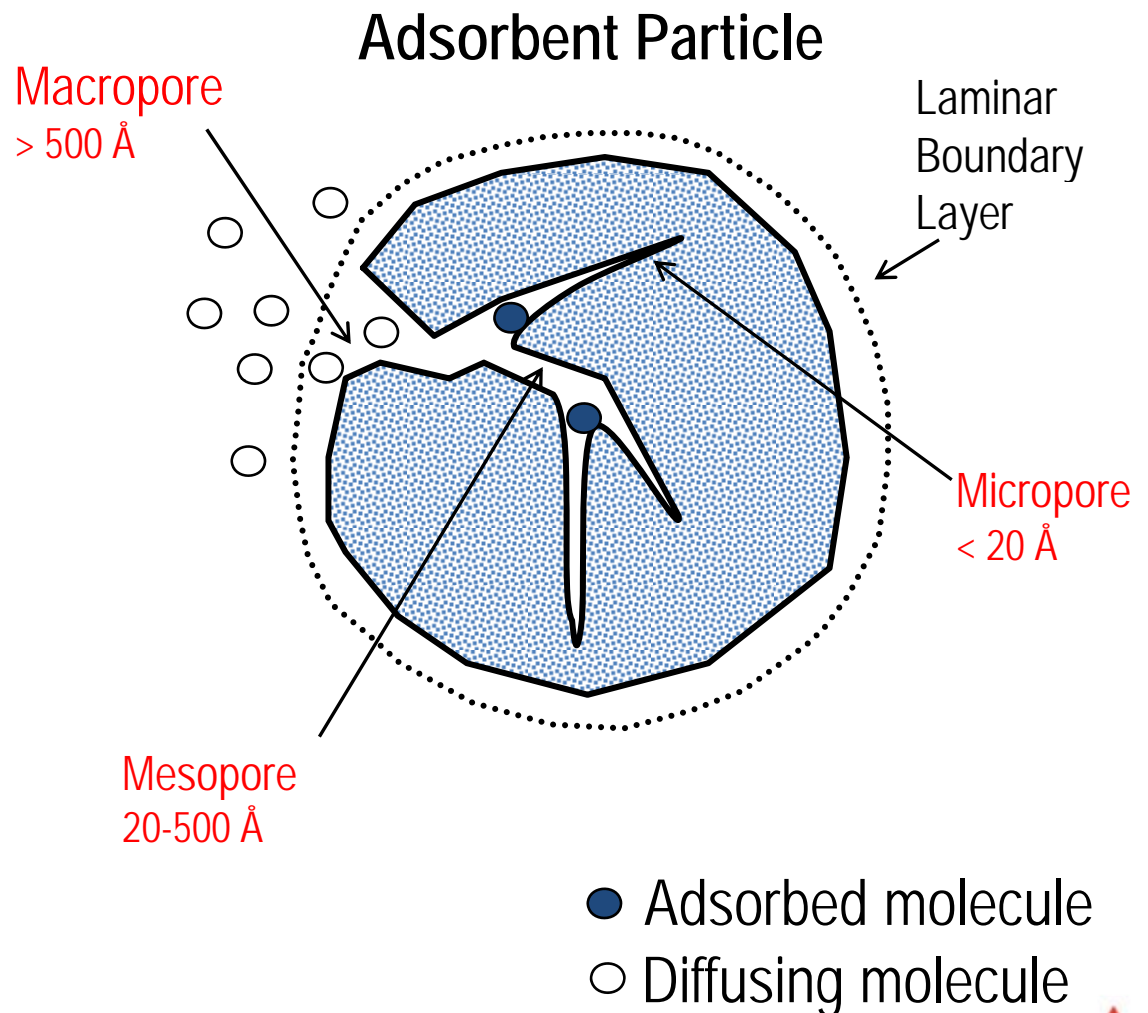
- 5 μm to 1.2 cm
- 300 to 1,200 m^2/g
- 30 to 85 vol%

Steps:

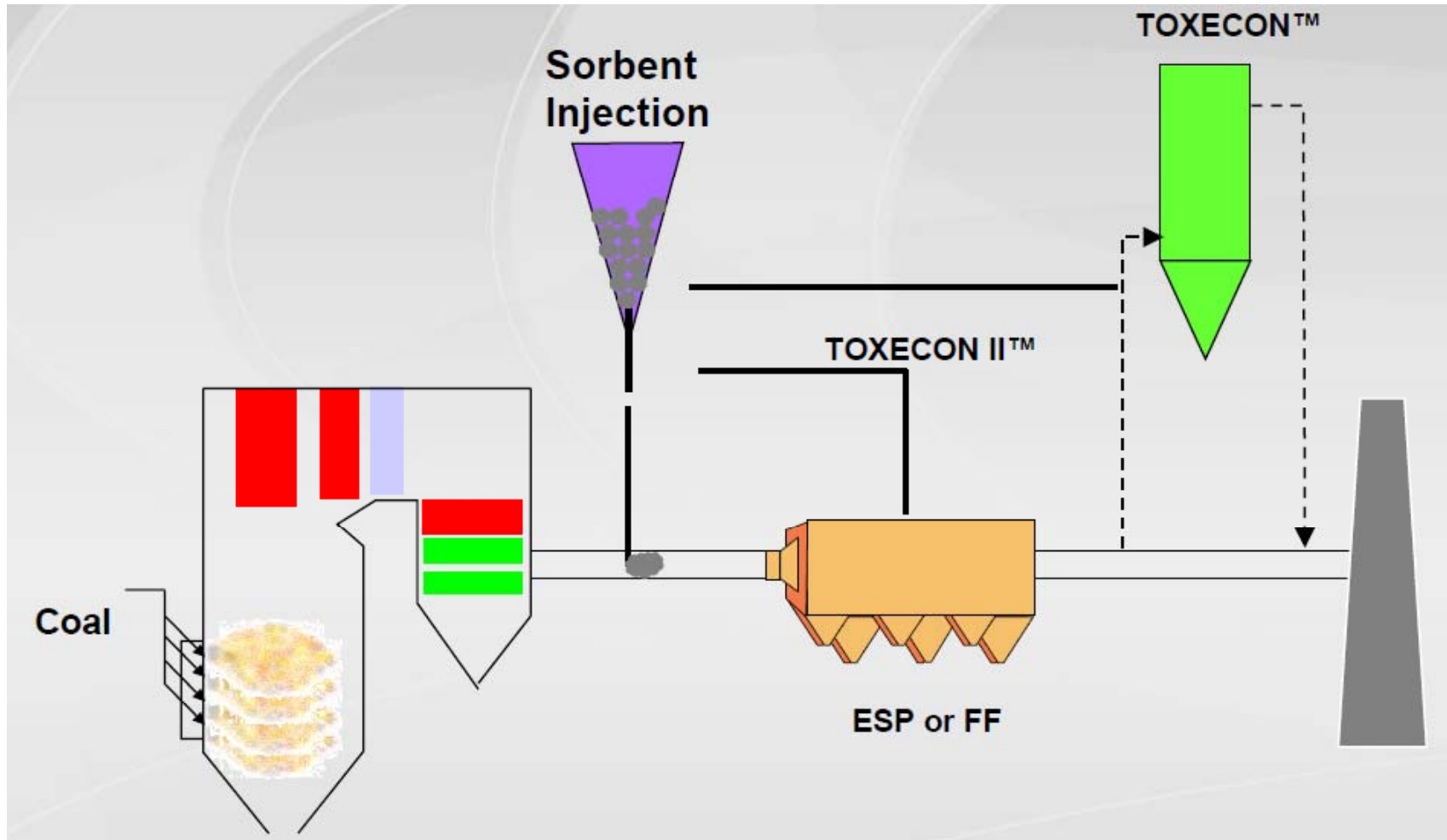
1. External diffusion
2. Internal Diffusion
3. Adsorption (physical or chemical)

Applications:

- water treatment
- Air pollution control



The Concept



Compliments of ADA.ES

**Flue Gas
Temperature**

450 °F

Other Factors
Coal Type
Control Equipment
Mass Transfer
Particle dispersion
Residence time
Sorbent Quality

**Injection Rate
&
Sorbent Type**

halogen
non-halogen

0 lb/Macf

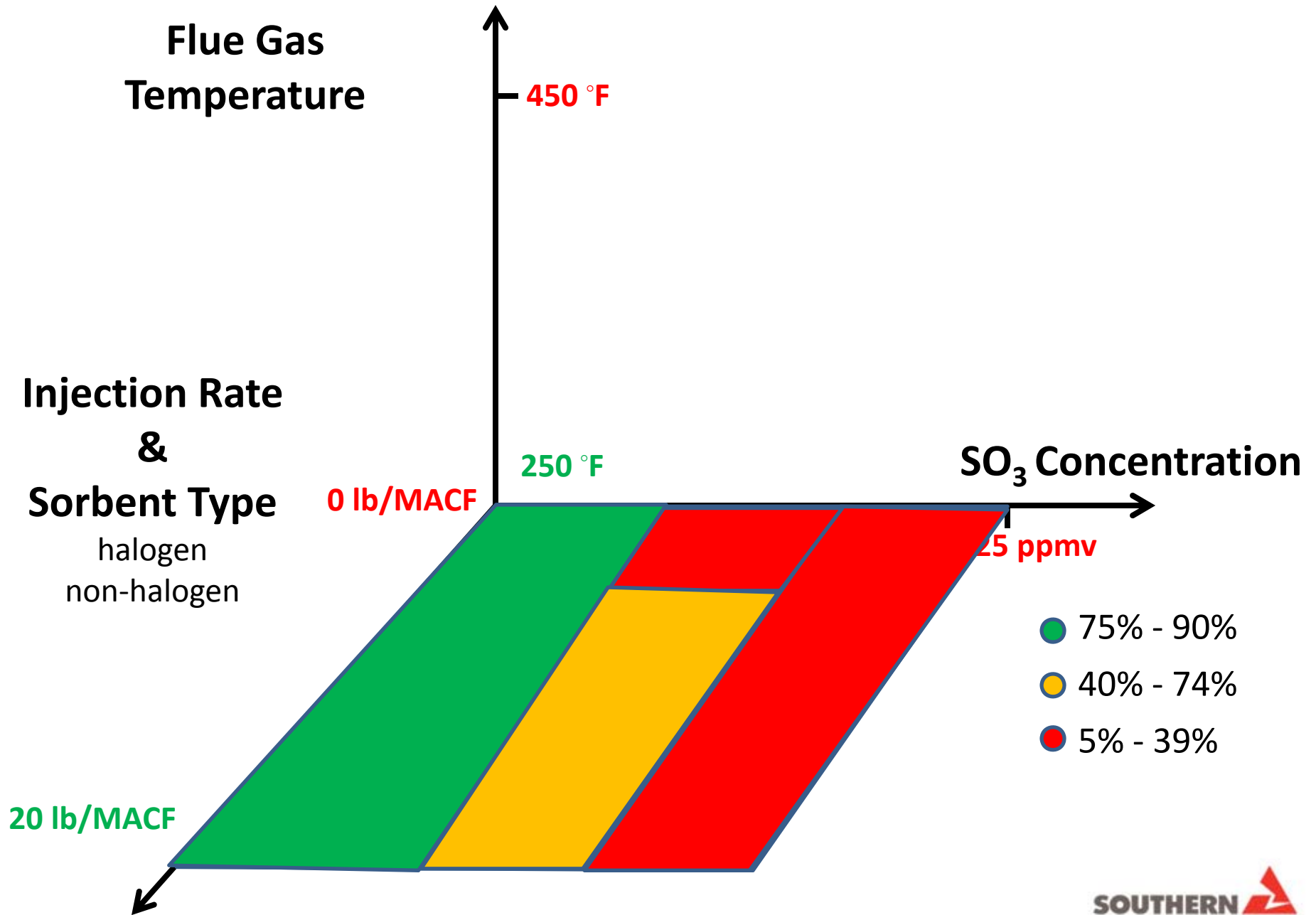
250 °F

0 ppmv

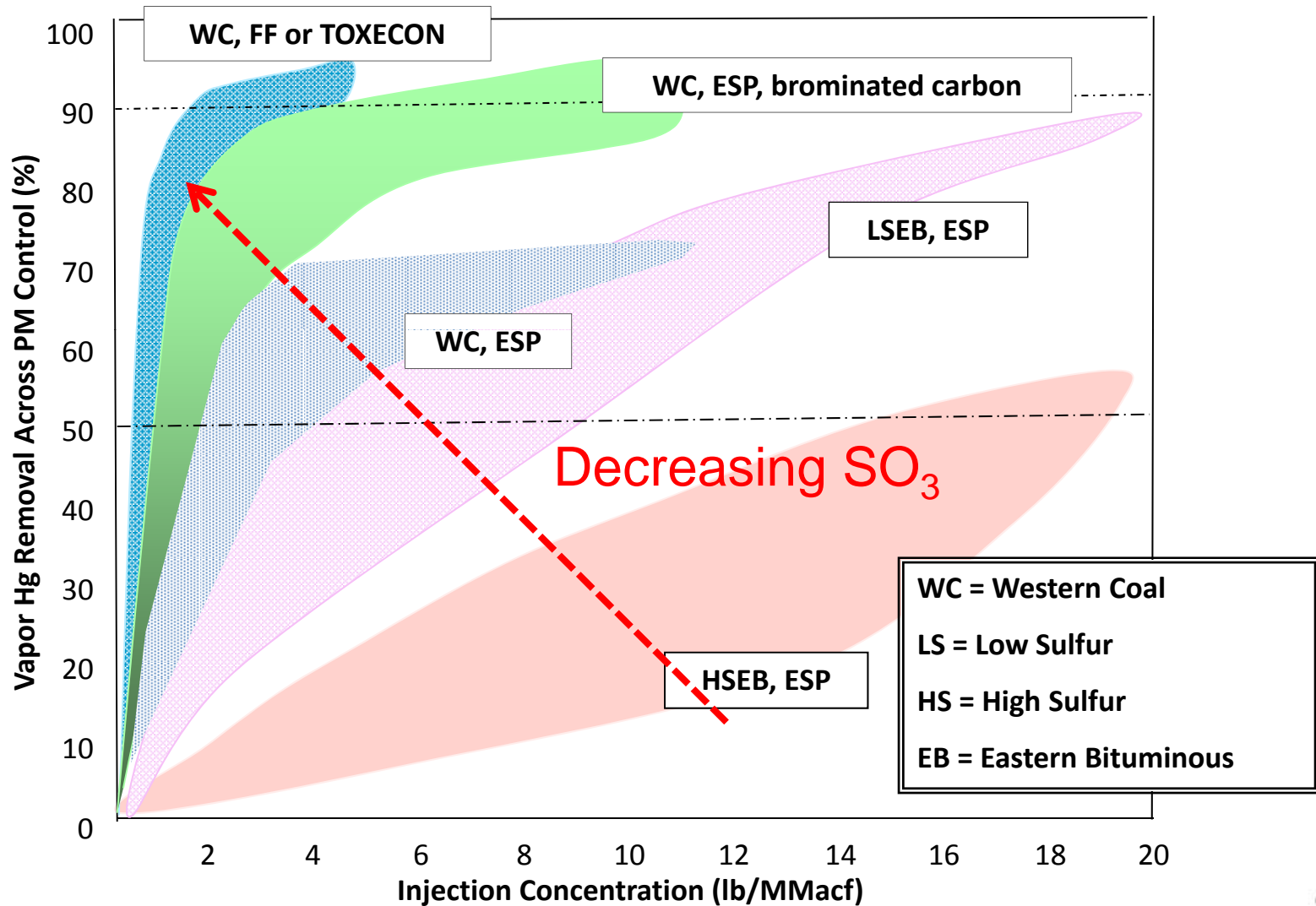
SO₃ Concentration

> 25 ppmv

20 lb/Macf

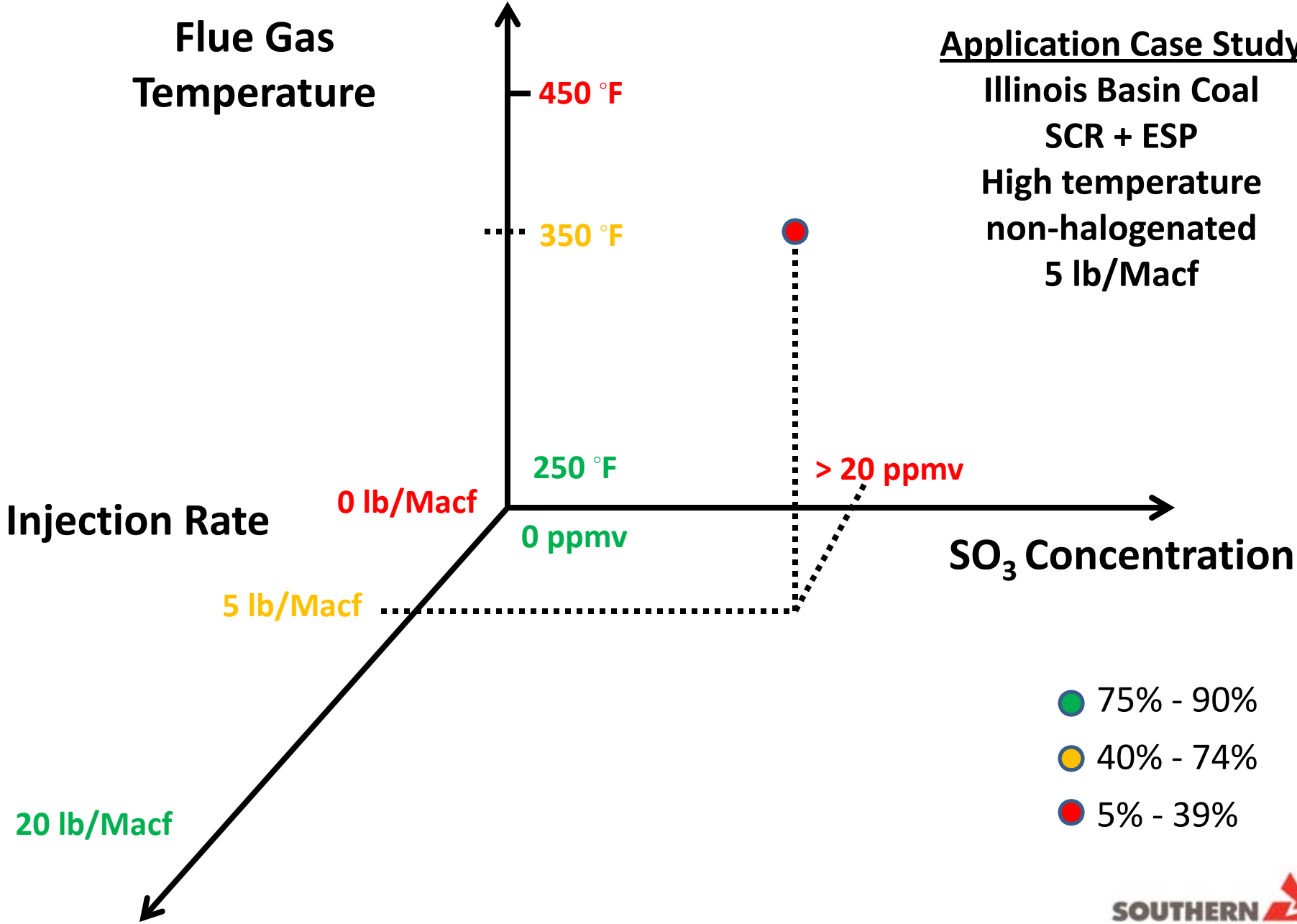


Activated Carbon Removal Trends

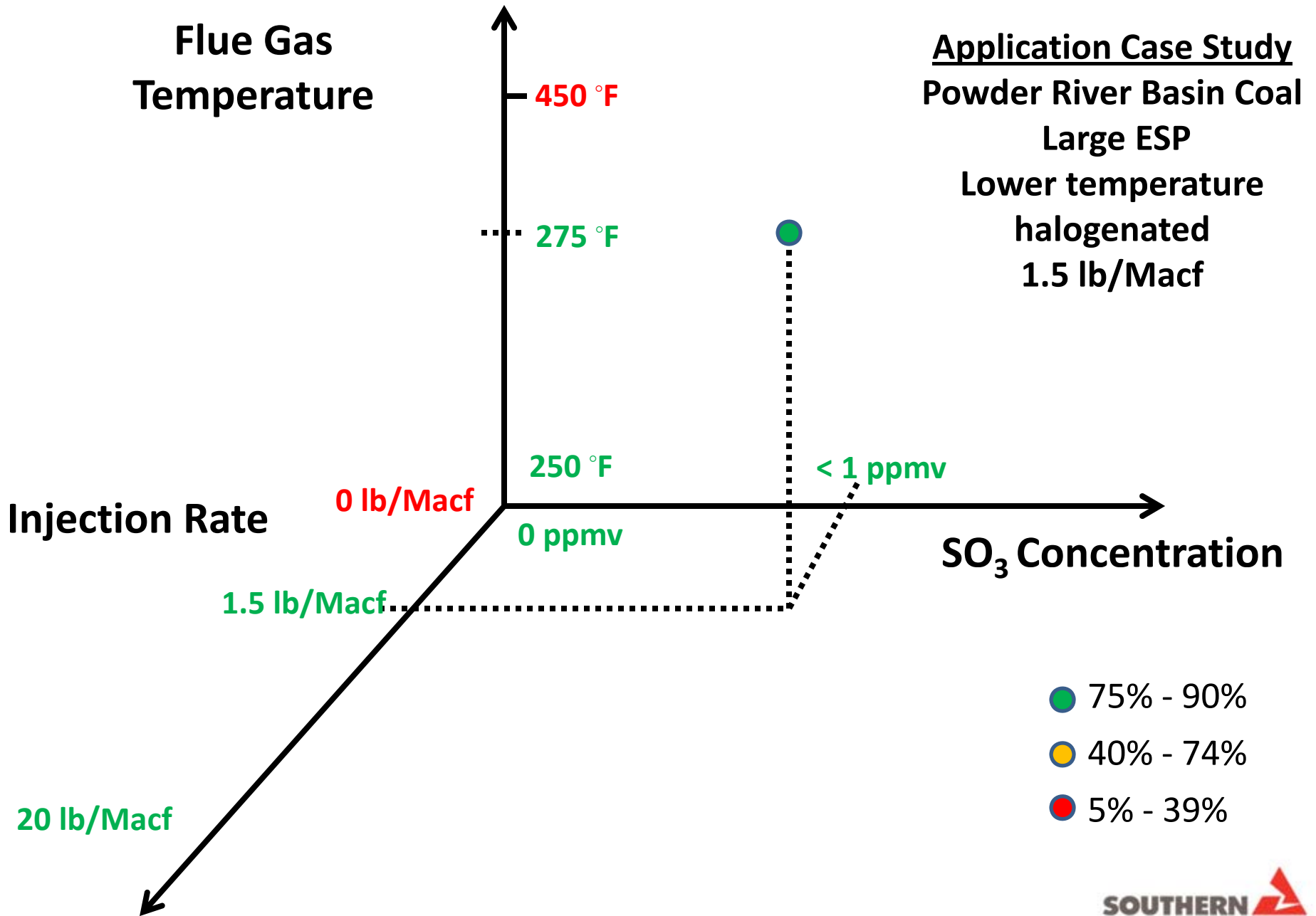


Application Case Study

Illinois Basin Coal
SCR + ESP
High temperature
non-halogenated
5 lb/Macf



- 75% - 90%
- 40% - 74%
- 5% - 39%

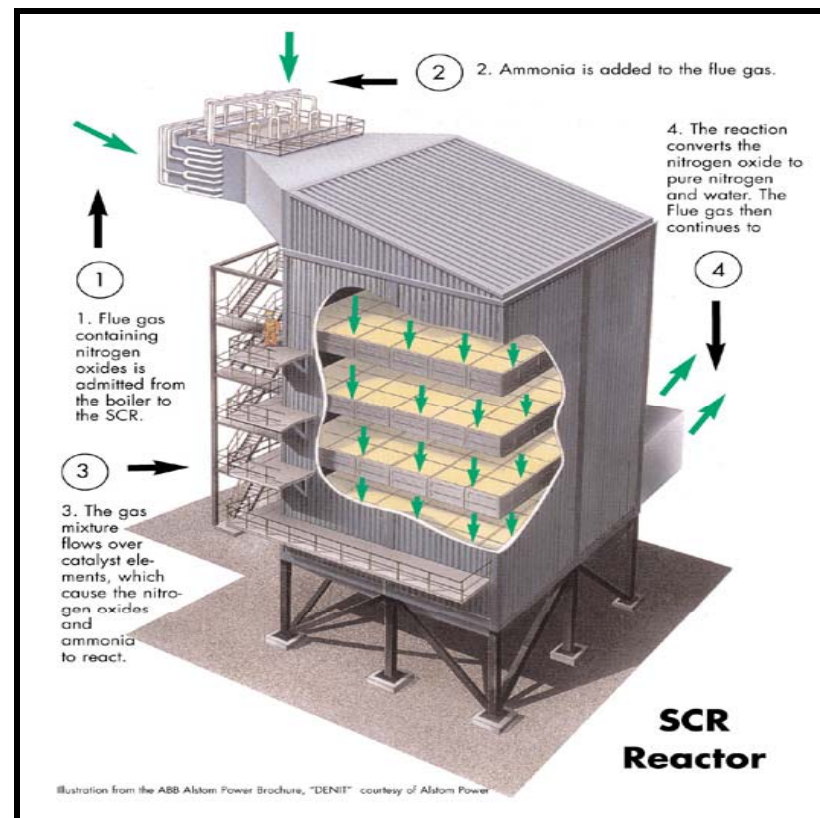


Performance Improvement Techniques

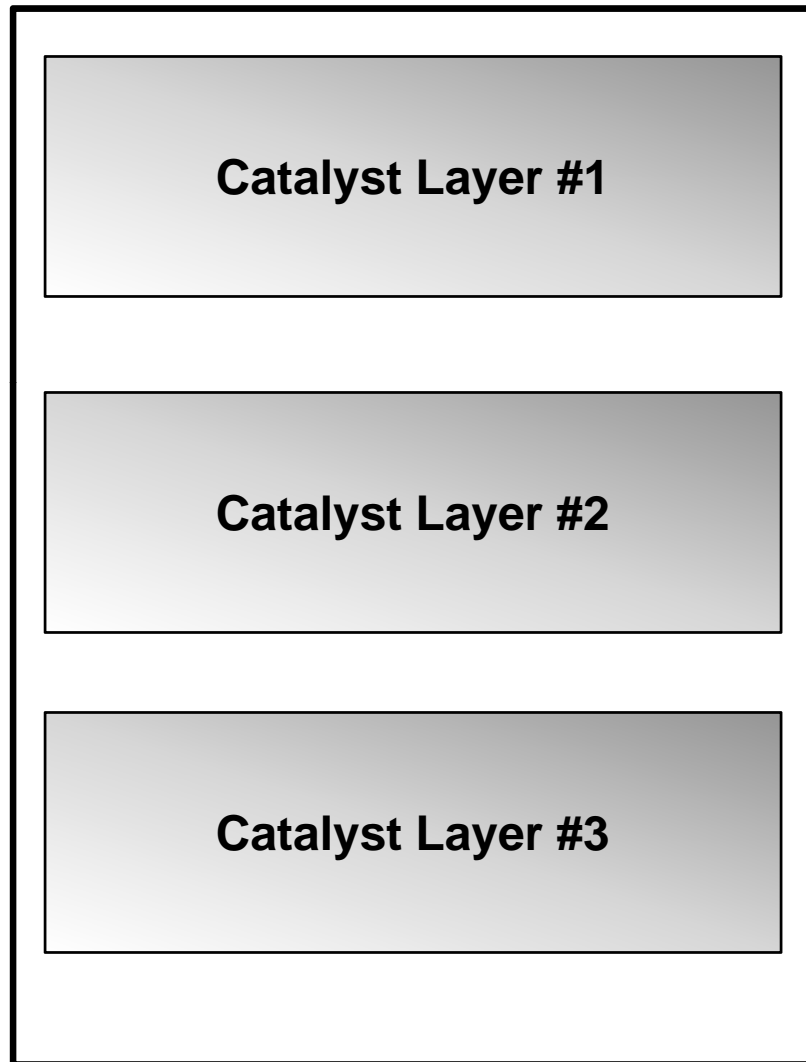
- **Decrease SO₃ Interference**
 - Use of Alkali sorbents
 - Change Fuels
 - Eliminate flue gas conditioning
- **Decrease Temperature**
 - Capital upgrades (Air heater modifications)
- **Designer Carbons**
 - Higher S tolerance
 - Chemically treated carbons
- **Increase residence time + improve dispersion**
- **Increase mass transfer characteristics (i.e. baghouse)**

Hg Oxidation Technology

- Occurs as a byproduct of the NO_x to N_2 reduction process
- Competes with same sites a $\text{NH}_3 + \text{NO}_x$ reaction sites
- Special Hg Oxidation SCR catalyst formulations available
- Halogen content of the coal
- Coal Cl promotes oxidation
- Halogen can be added to promote oxidation

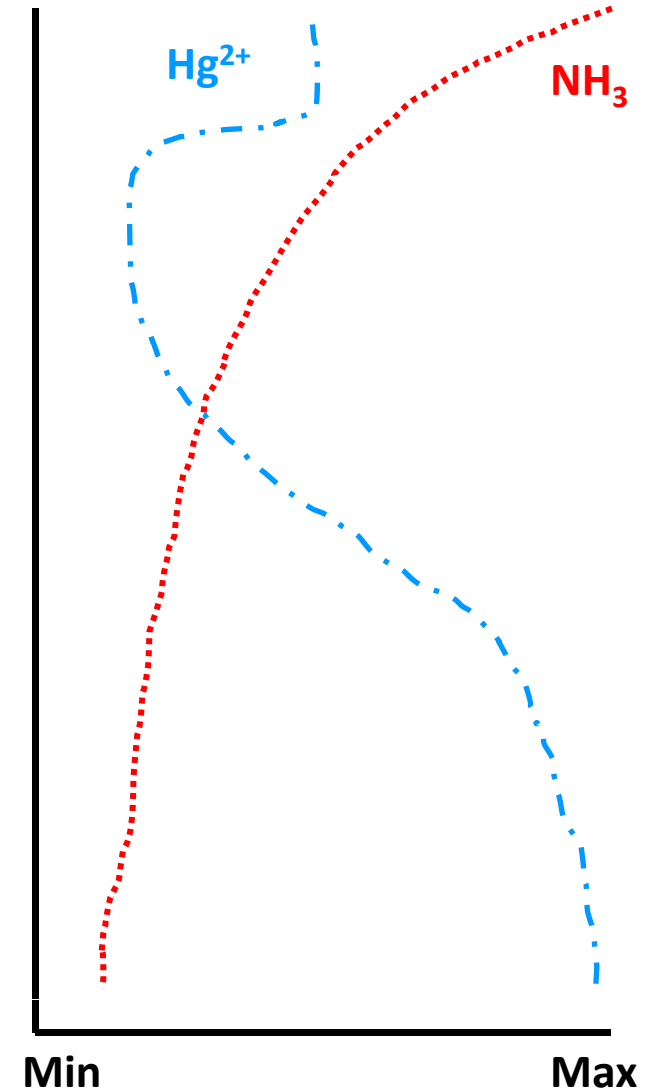


Hg Behavior Correlates w/ SCR Operations

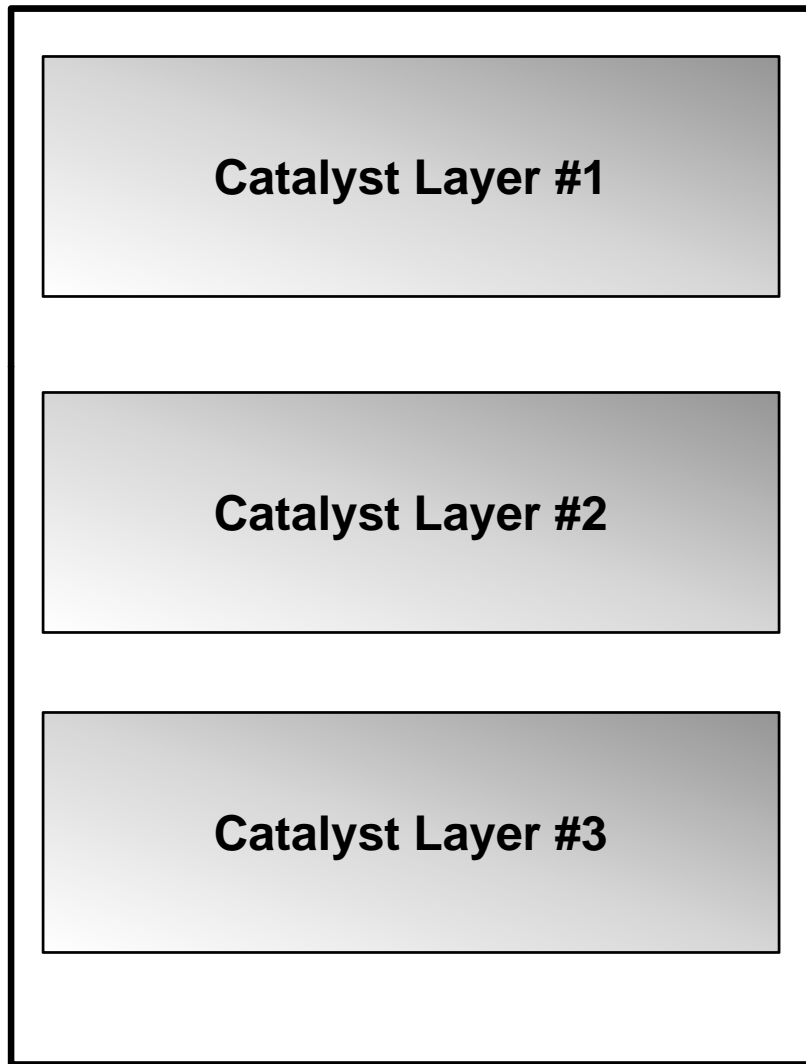


Gas Flow

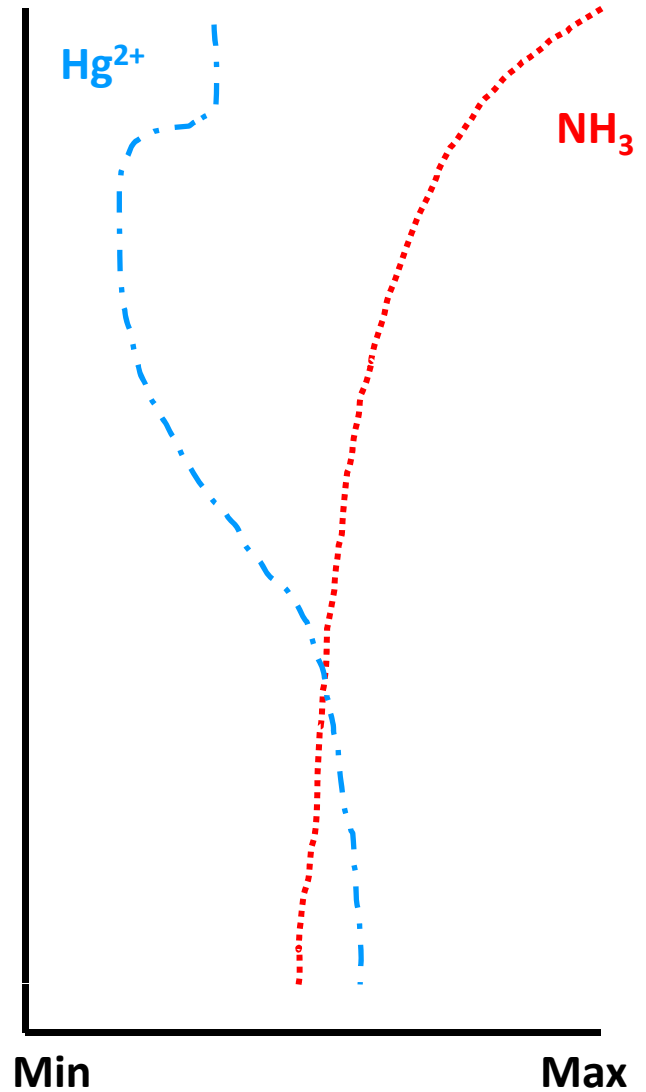
A thick black arrow points downwards from the top of the catalyst layers, indicating the direction of gas flow through the reactor.



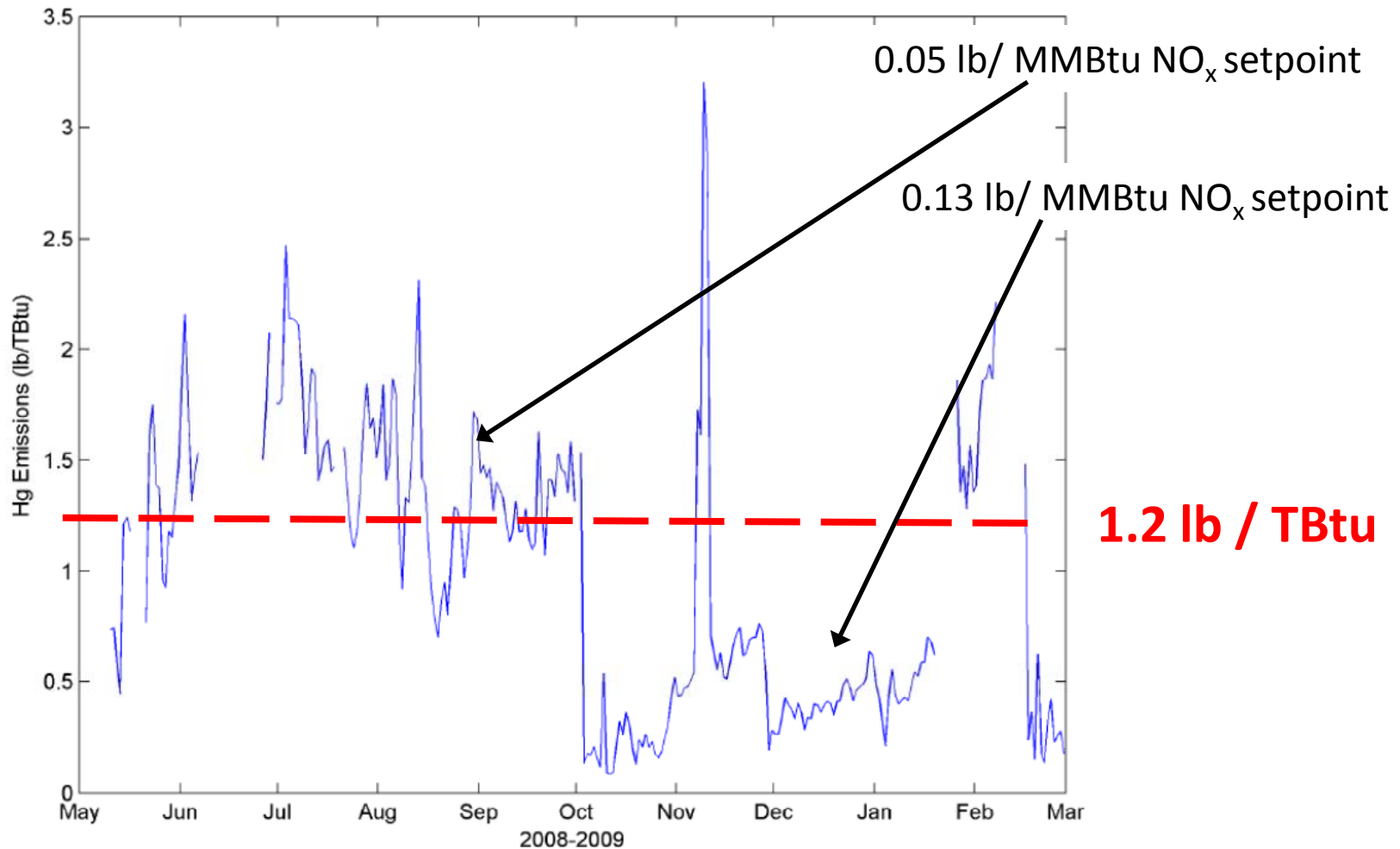
Hg Behavior Correlates w/ SCR Operations



Gas Flow



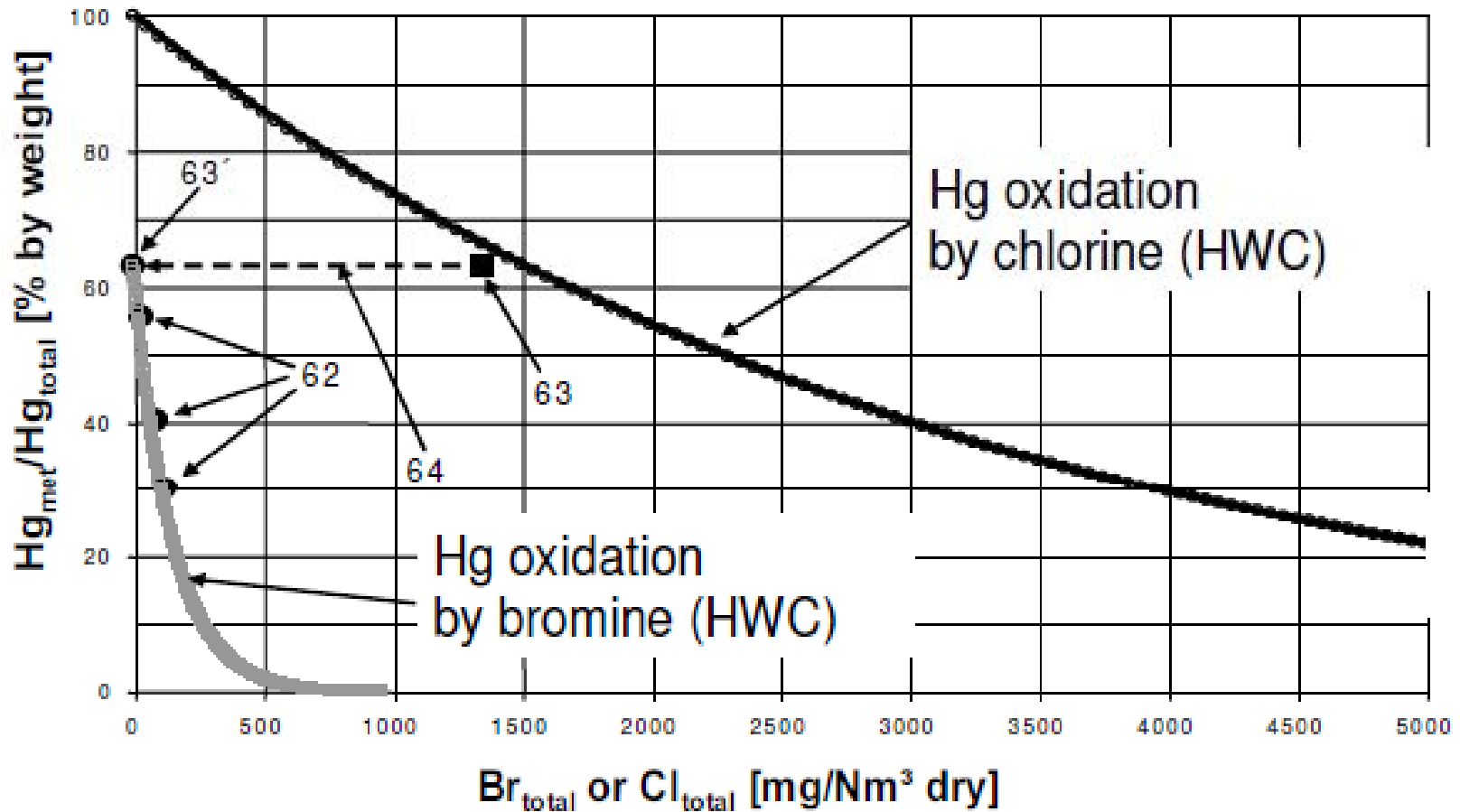
Hg Emissions Correlates w/ SCR Operations



900 MW Eastern bit unit with SCR and wet FGD

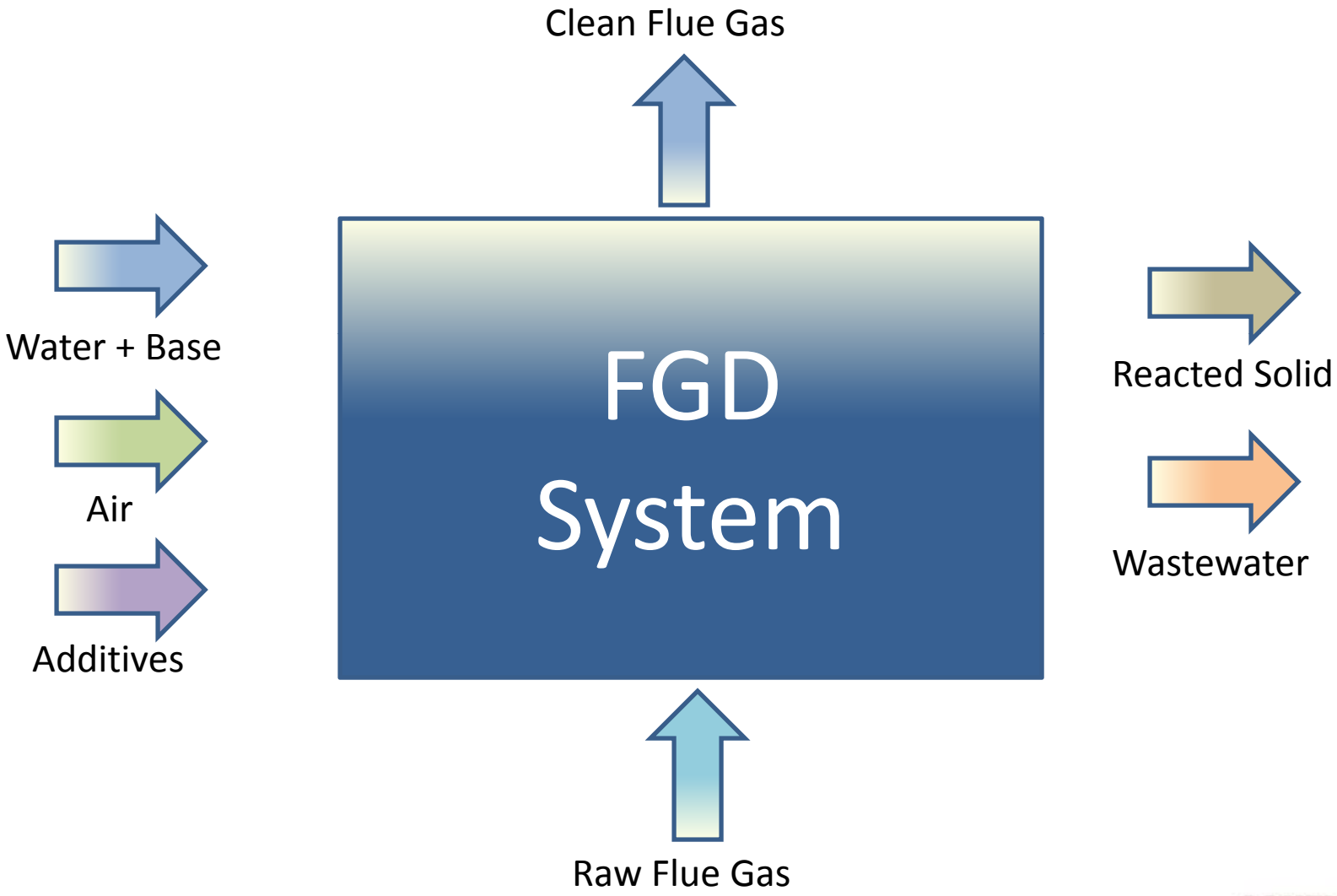


Bromine vs. Chlorine

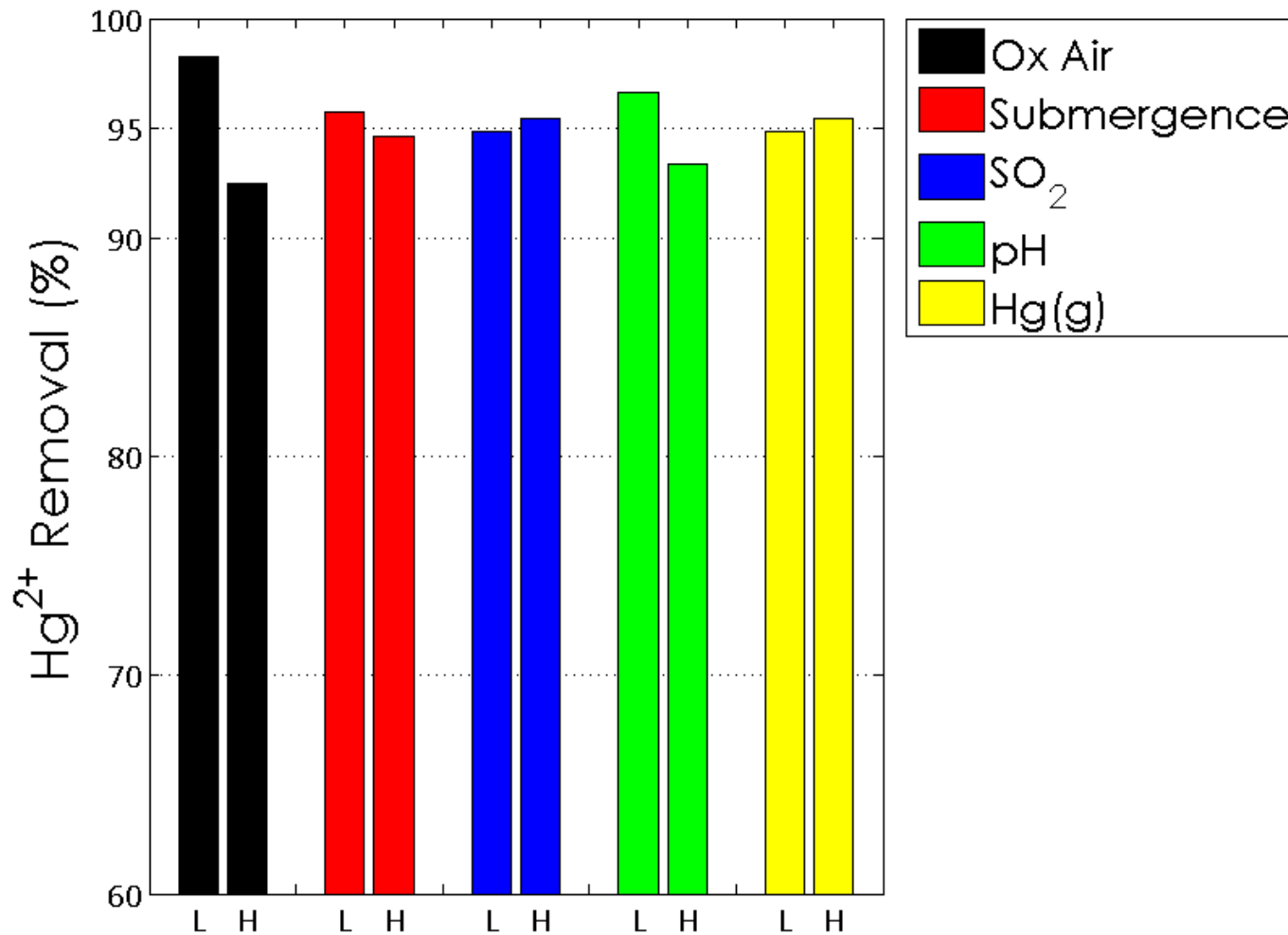


Provided by Bernhard Vosteen

SO₂ Scrubbers



Variables that affect Hg^{2+} capture



Oxidized mercury capture averaged 95% and was independent of fuel S, fuel Hg, liquid submergence, pH, and oxidation air.

Performance Improvement Techniques

Increase Hg Oxidation

- Purchase Hg Oxidation Catalyst
- Replace catalyst more frequently
- Increase halogen content artificially
- Decrease NH_3 concentration
- Decrease flue gas temperature

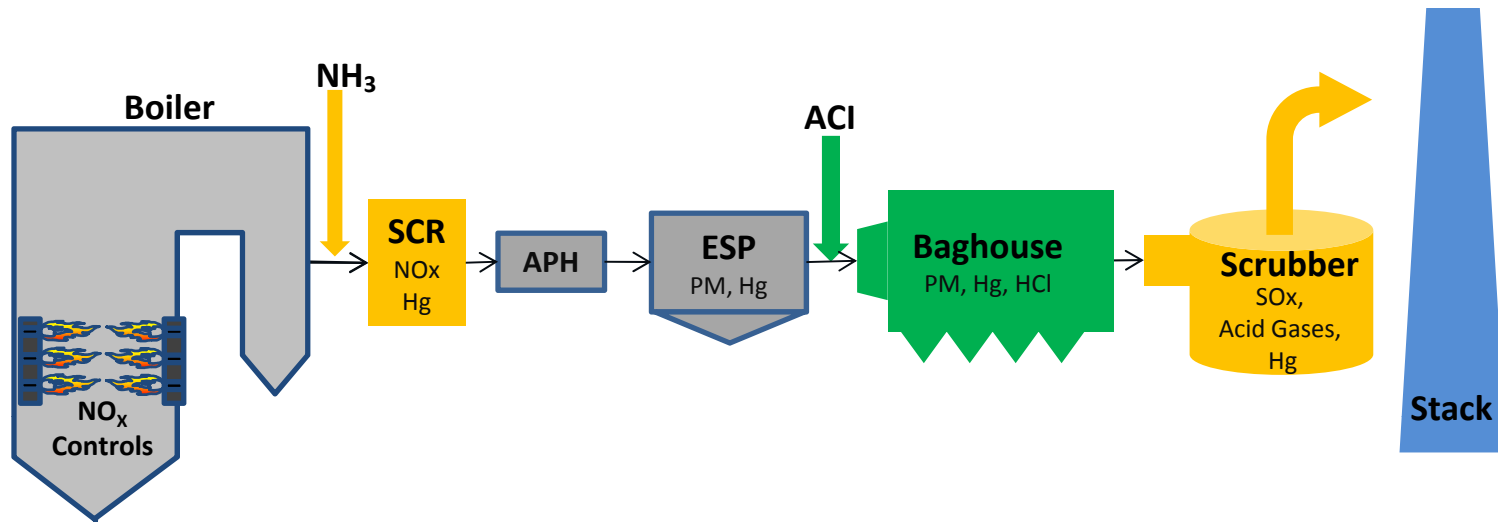
Manage wet FGD operations

- Minimize Hg re-emissions
 - Use of chemical additives



Mercury Research Center
Pilot wet FGD

Example – “What Happens to Mercury”



	Boiler	Boiler Exit	SCR	ESP	TOXECON	FGD	Removal
Hg^0	10						
Hg^{2+}	0						
Hg^T	10						
Removal							