REINHOLD ENVIRONMENTAL Ltd.

2012 APC Round Table & Expo Presentation

July 16-17, 2012, in Baltimore, MD / Hosted by Duke Energy, Entergy, FirstEnergy, Southern Company & TVA

Increase Mercury Capture Efficiency of Wet FGDs

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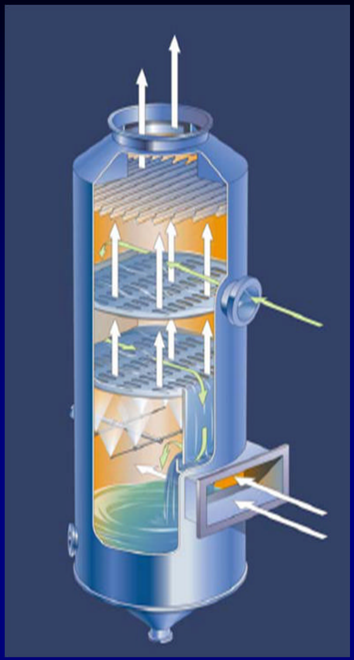
Presentation Outline

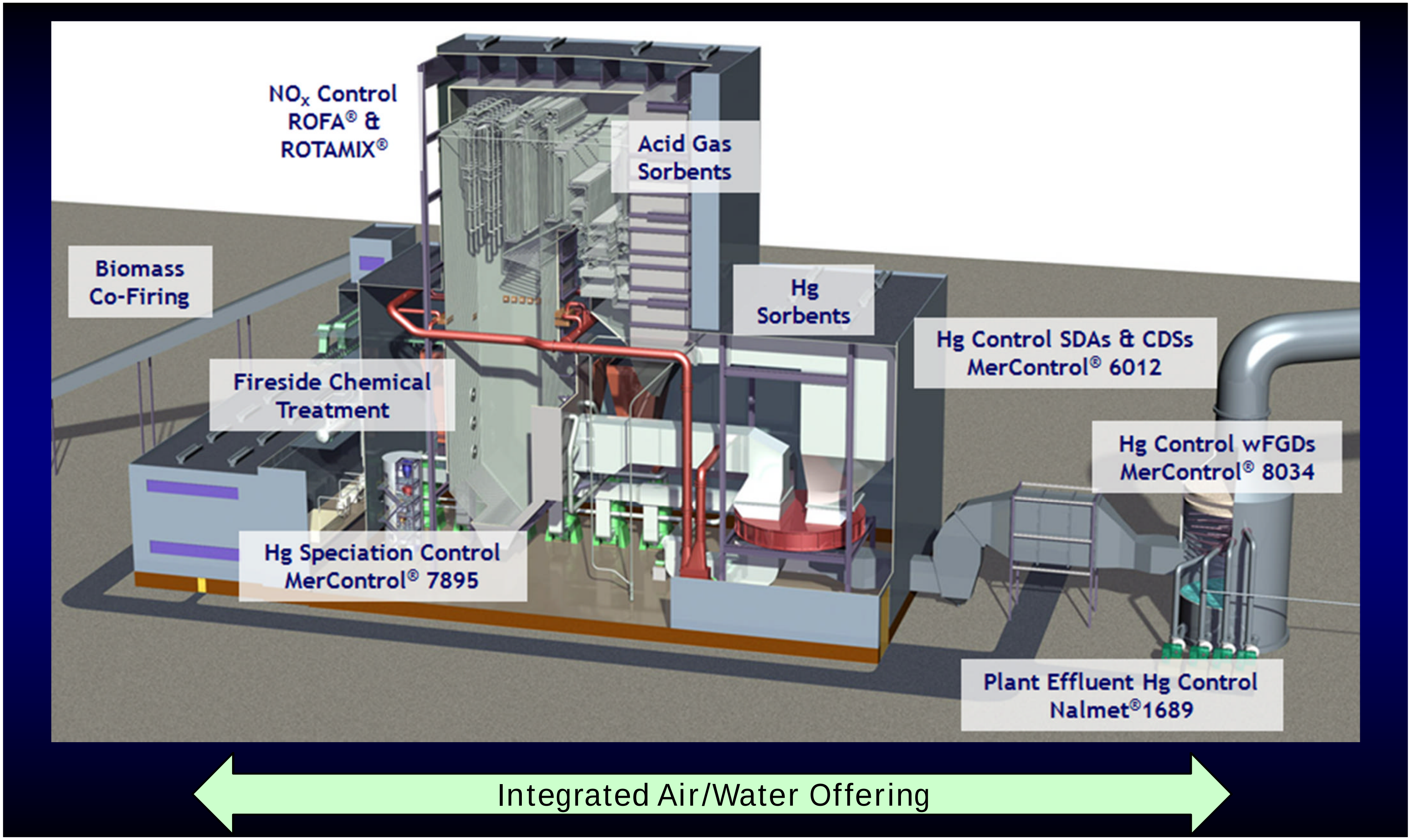


Sustaining Clean Air and Water

- Background Information
- Role of Hg Speciation
- Role of Hg Re-emissions
- Site Results
- Impact on Balance of Plant
- Summary/Questions

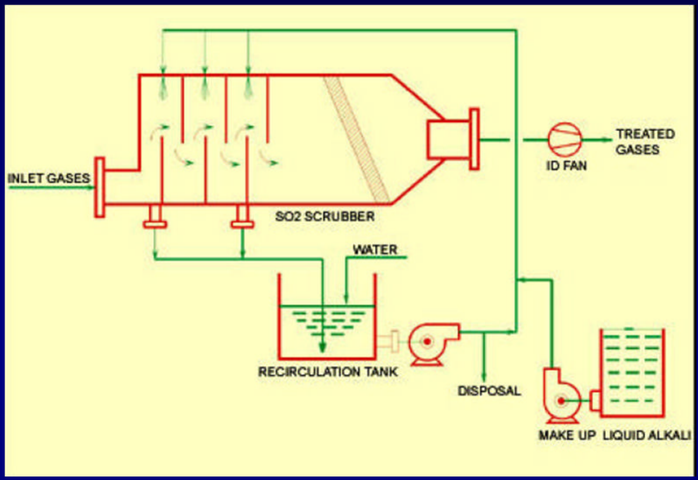
www.airpol.com/wetscrubbers.

"Small Environmental Footprint"
Coal-Fired Power Plant

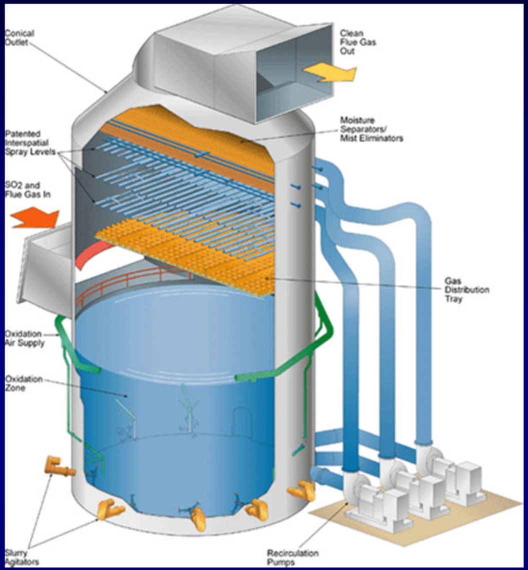


Example wFGD Types and Operations

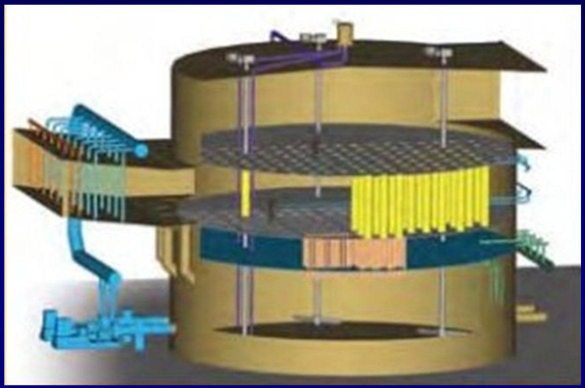
Fuel Types: bituminous and subbituminous



Horizontal scrubber[1]



Tower scrubber[2]



Jet bubbling reactor (JBR)[3]

Chemistries such as forced oxidation limestone, magnesium-enhanced inhibited oxidation, and sodium based scrubber liquor.

1. www.fluegasdesulfurization.com
2. www.ducon.com/limestone-fgd.php
3. www.bv.com/downloads/Resources/brochures/rsrc_ENR_FirstWetFlueGasDesulfurization.pdf

Hg Re-emission Across wFGD

- Wet FGDs are capable of 90+% capture of oxidized Hg.
- Then why is the observed range 50-80% capture?
- What limits compliance of EGUs with this configuration?

Hg Speciation

Hg Re-emission

Definition:

$$[Hg^0]_{stack} > [Hg^0]_{w\text{-}FGD\ inlet}$$

$$Hg^{2+}_{(aq)} \rightarrow Hg^0_{(g)} \uparrow$$

$$[HgSO_3 + H_2O \rightarrow Hg^0 + H_2SO_4]$$

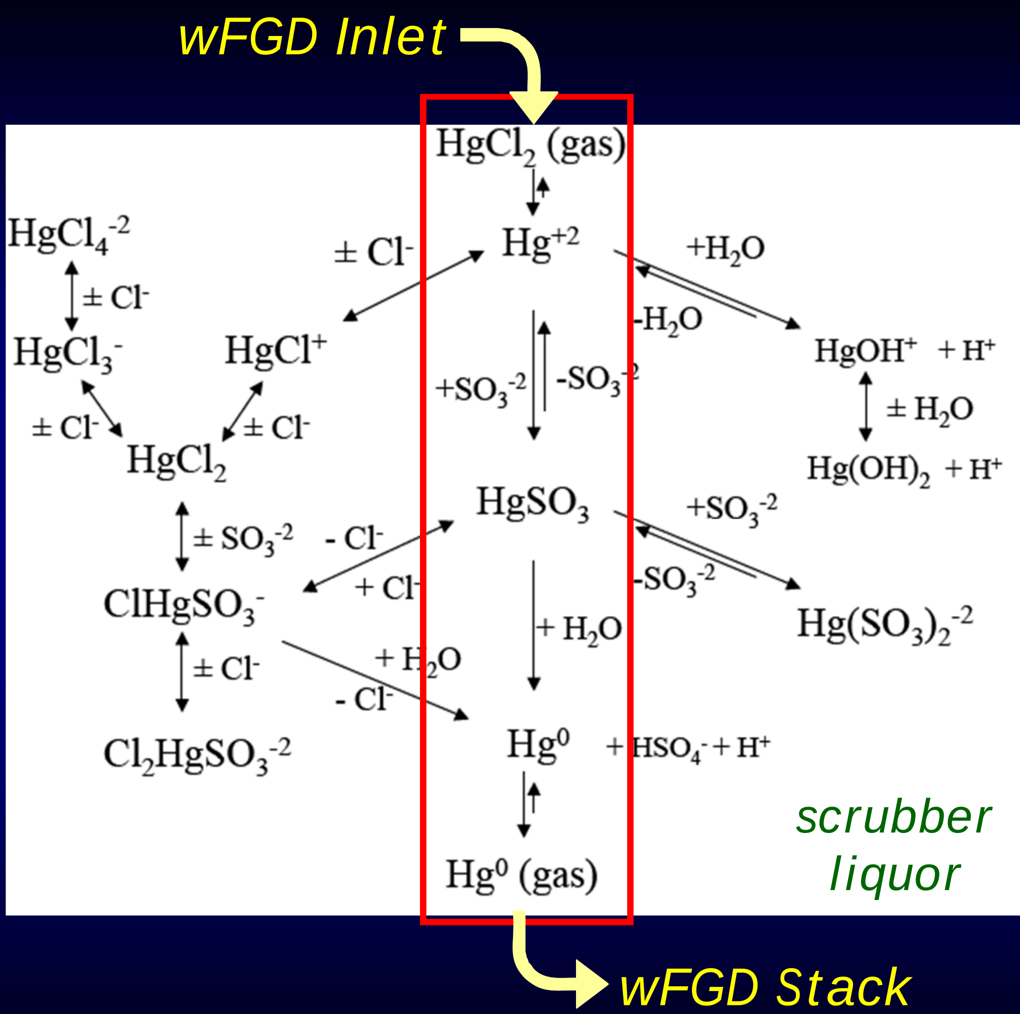
Suggested Reading:

"Bench-scale Kinetics Study of Mercury Reactions in FGD Liquors" Blythe, G. M.; DeBerry, D. W.; April 2007.

"Preventing Mercury Re-emissions in wet Flue Gas Desulfurization Scrubbers at Coal-fired Power Plants using MerControl® 8034 Additive" Stiles, R.L; et al. Preprints of Symposia - American Chemical Society, Division of Fuel Chemistry (2010), 55(1), 164-166.

"Demonstrating Mercury Emissions Reduction Cost Management" Meier, J.; Keiser, B.A.; and Higgins, B.; Air Quality VIII, Arlington, VA; 2010.

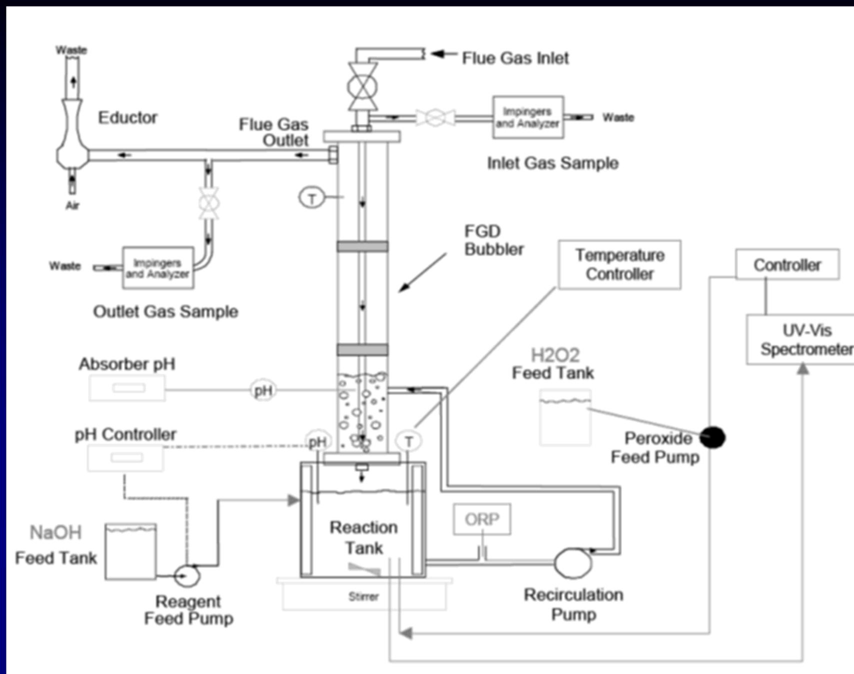
Hg Re-emission Chemistry in wFGDs

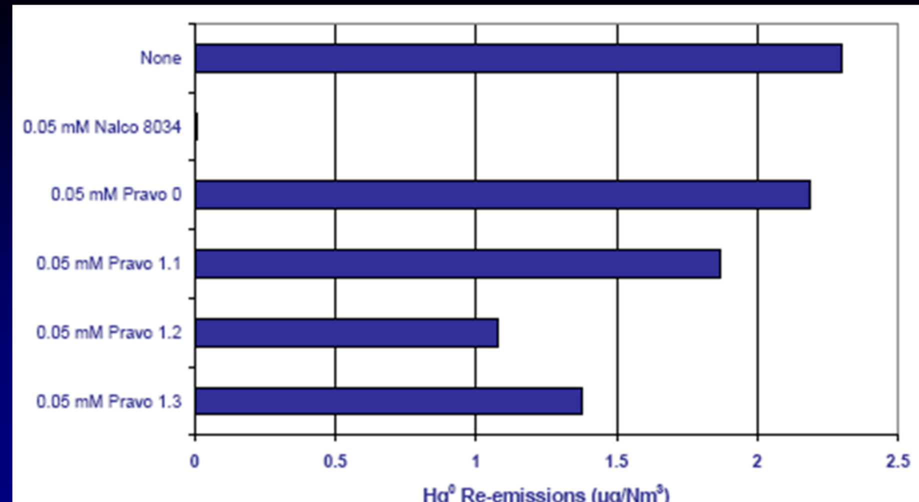


- Scrubber Operations impact magnitude.
- Some known variables include: pH, sulfite, type of alkali, oxidation, etc.

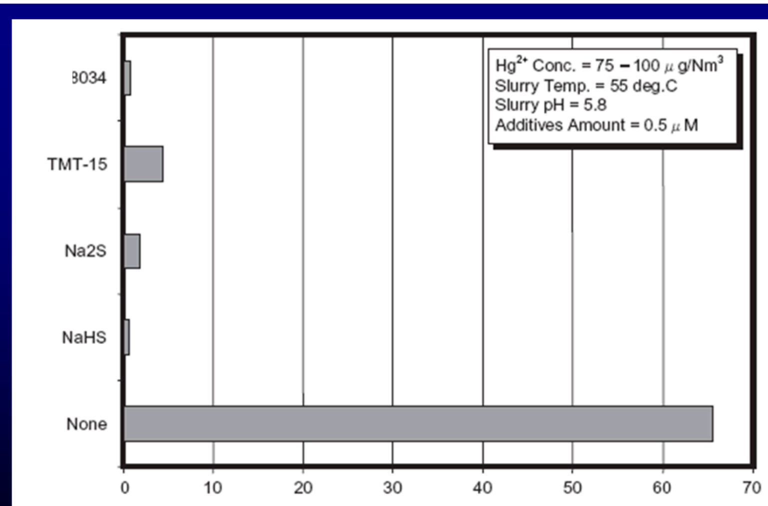
"Bench-scale Kinetics Study of Mercury Reactions in FGD Liquors" Blythe, G. M.; DeBerry, D. W.; April 2007

Independent Lab Simulations





pH 5, 100mM Cl, 55°C (ref 1)

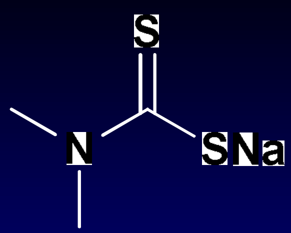


(ref 2)

Lab Studies on operational variables and potential additives.

1Gary M. Blythe, John Currie, and David W. DeBerry, "Bench-Scale Kinetics Study of Mercury Reactions in FGD Liquors," Final Report, September 30-2004 – March 31, 2008, August 2008 Cooperative Agreement No: DE-FC26-04NT42314.
[2]Naruhito Omine, Carlos E. Romero, Hirofumi Kikkawa, Song Wu, and Sandhya Eswaran, "Study of elemental mercury re-emission in a simulated wet scrubber," *Fuel*, 2012, *91*, 93-101.

Structure of Some Mercury Chelants

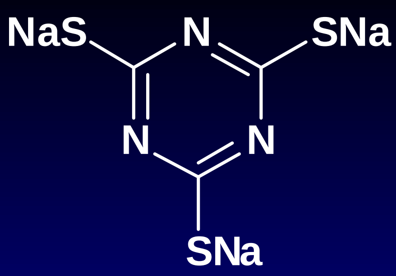


Dimethyl dithiocarbamate

(DTC)

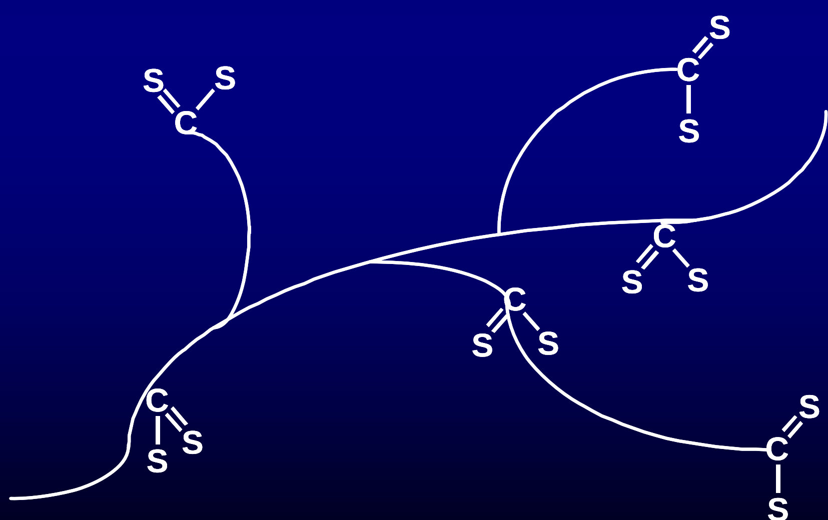
NaHS

Sodium Hydrosulfide



1,3,5-triazine-2,4,6(1H,3H,5H)-trithione

Trimercaptotriazine (TMT)



MerControl 8034 Technology

(*poly*-dithiocarbamate)

Patented Technology

MerControl 8034 Application

Simple application equipment, low capital cost and application point simplicity.

Site I: Mercury Re-emission Control

Site Description

- Full Load = 513 MWg
- Boiler Type = tangential pulverized coal
- Fuel = bituminous coal
- AQCDs = cold-side ESP, LSFO wFGD

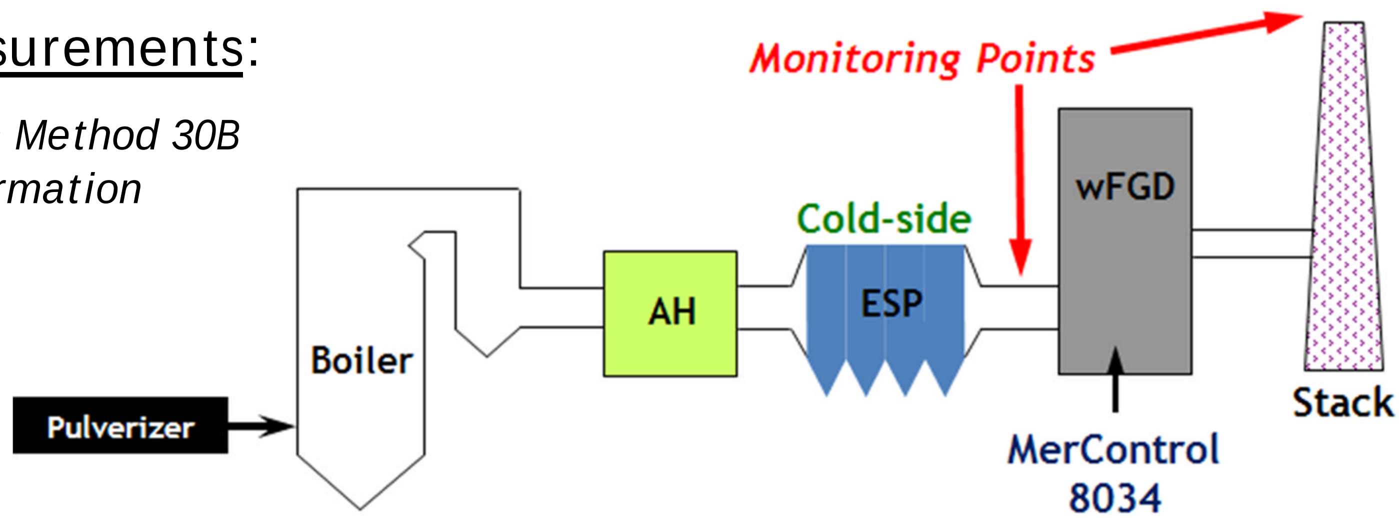
Coal Quality

- Sulfur = 3.06 ± 0.38 % (dry)
- Chlorine = 409 ± 154 ppm
- Mercury = 0.088 ± 0.026 ppm

Goal: Control Mercury Re-emission across the wFGD to maximize mercury capture.

Hg measurements:

CMMs with Method 30B confirmation



LSFO = Limestone forced oxidation

Equations used in Presentation

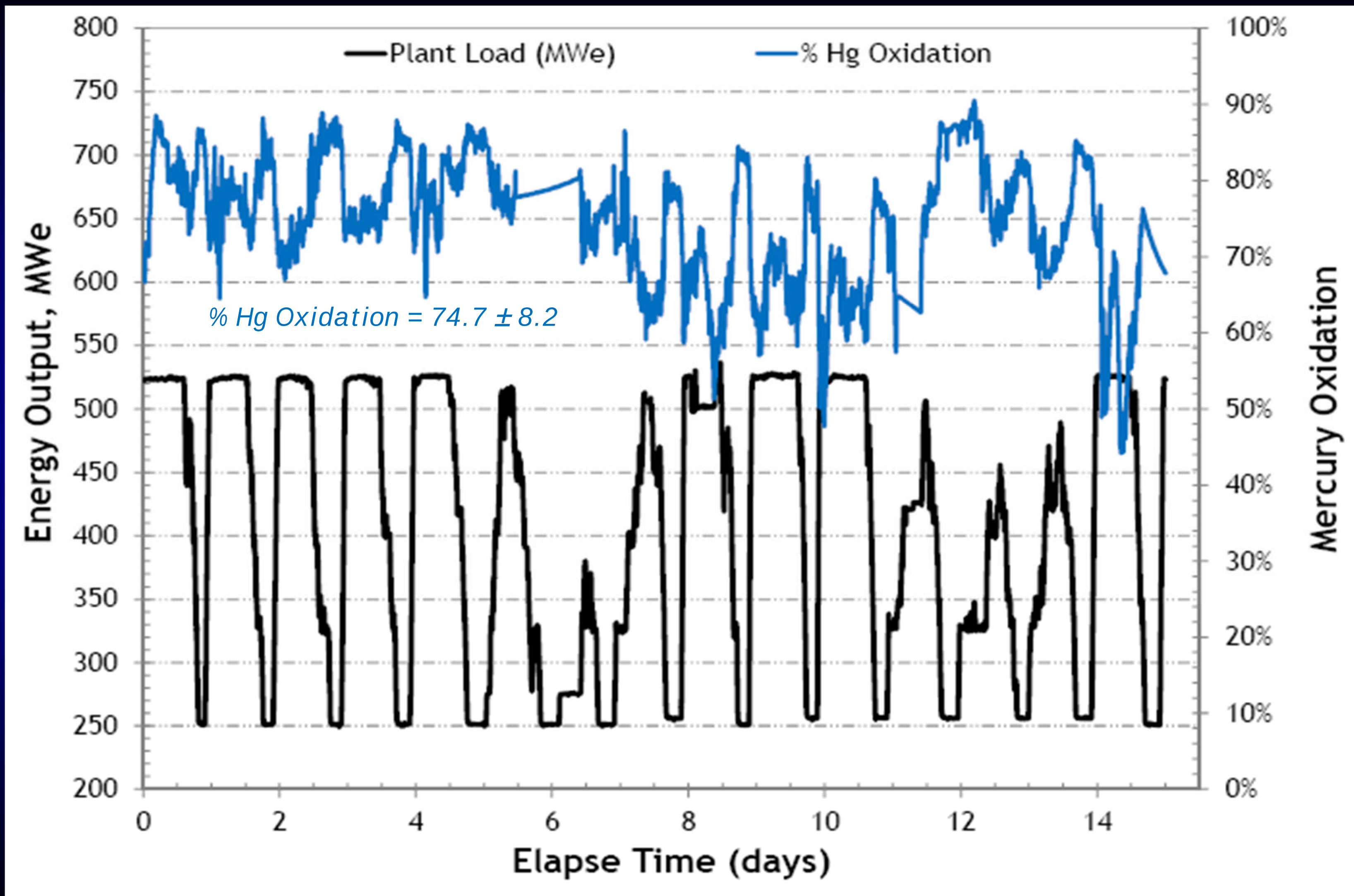
$$\% \text{ Hg Capture} = \left(\frac{Hg^{T}_{Inlet} - Hg^{T}_{outlet}}{Hg^{T}_{Inlet}} \right) \times 100$$

$$\% \text{ Hg Re-emission} = \left(\frac{Hg^{0}_{outlet} - Hg^{0}_{inlet}}{Hg^{T}_{Inlet} - Hg^{0}_{Inlet}} \right) \times 100$$

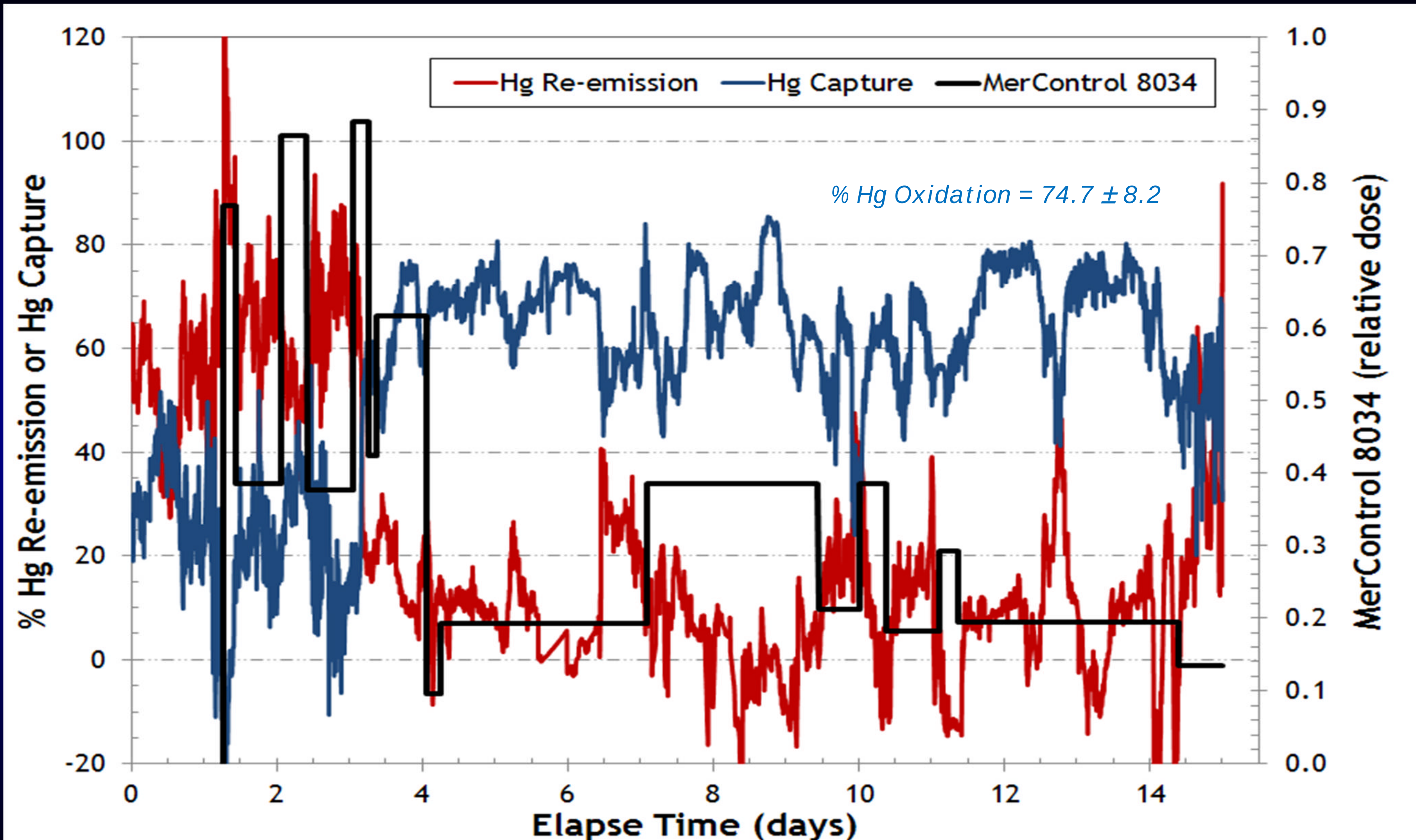
$$\% \text{ Hg Oxidation}^{1} = \left(\frac{Hg^{T}_{Inlet} - Hg^{0}_{inlet}}{Hg^{T}_{Inlet}} \right) \times 100$$

[1] *Note: Applicable to inlet or stack measurement.*

Site I: Plant Operations



Site I: Performance Confirmed



Site I: Summary of Performance

Comparison	Elapse (Days)	Percent			
		Oxidation	Re-emission	Capture	wFGD Efficiency
Baseline	0-1.4	79.5 ± 4.6	59.3 ± 21.0	23.7 ± 17.2	29.5 ± 21.3
MerControl 8034	4 - 14	73.9 ± 7.9	9.69 ± 10.8	65.5 ± 9.6	88.7 ± 11.2

wFGD Efficiency = Percent of inlet flue gas *ionic mercury captured* by wFGD.

$$\%\ \text{wFGD Efficiency} = \left(\frac{Hg^{T}_{inlet} - Hg^{T}_{outlet}}{Hg^{T}_{Inlet} - Hg^{0}_{Inlet}} \right) \times 100$$

MerControl 8034 application increased mercury capture and wFGD efficiency to greater than 88% .

Site II: Hg Capture via SCR and wFGD

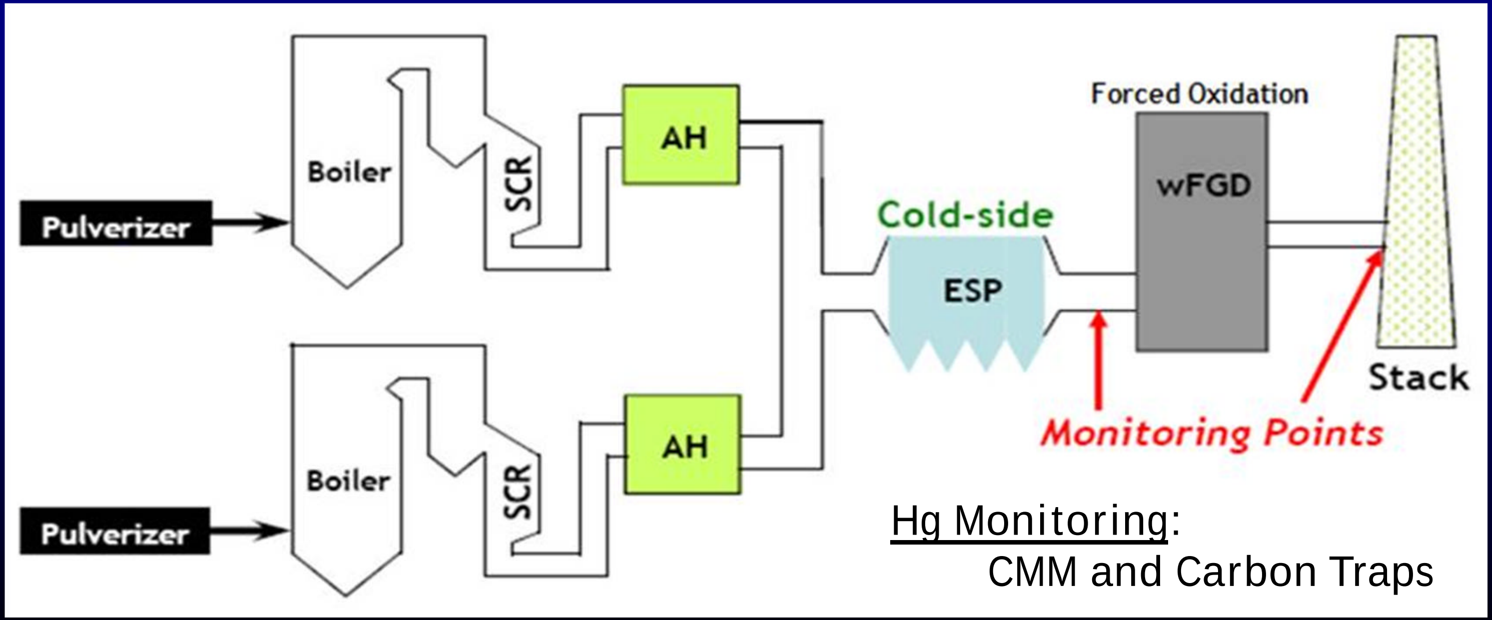
Site Description:

- Chlorine* = 1200 ppm (max = 1400)
- Mercury* = 0.05 ppm (max = 0.06)

- Full Load = Total 140 MWe
- Fuel = High Chlorine Bituminous
- AQCDs = SCR, cold-side ESP and wFGD

*= AR value

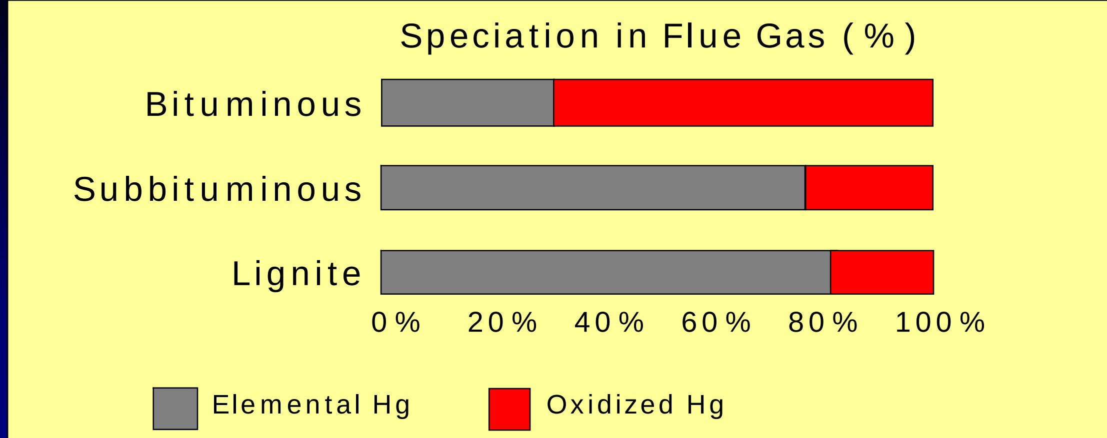
Goal: Reduce Hg re-emissions to meet regulator limit.



Mercury Emission Control & wFGD

Flue Gas Hg Speciation

$[Hg^0]_{gas}$ $[Hg^{2+}]_{gas}$



2000 Data per NETL at 2002 EPRI Workshop

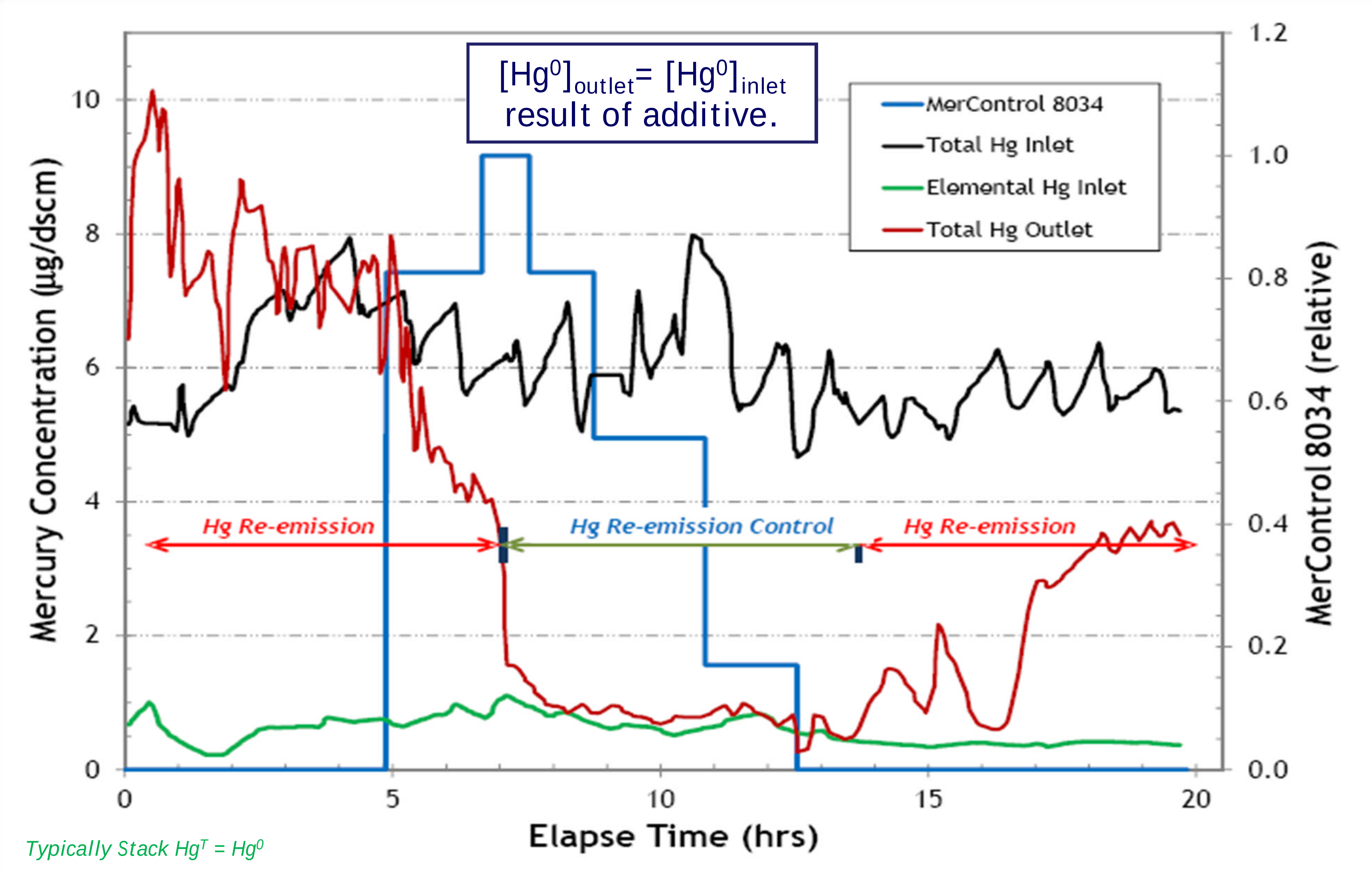
Hg Re-emission

$$[Hg^0]_{stack} > [Hg^0]_{WFGD\ inlet}$$

$$Hg^{2+}_{(aq)} \rightarrow Hg^0_{(g)} \uparrow$$

$$[HgSO_3 + H_2O \rightarrow Hg^0 + H_2SO_4]$$

Site II: Performance Confirmed



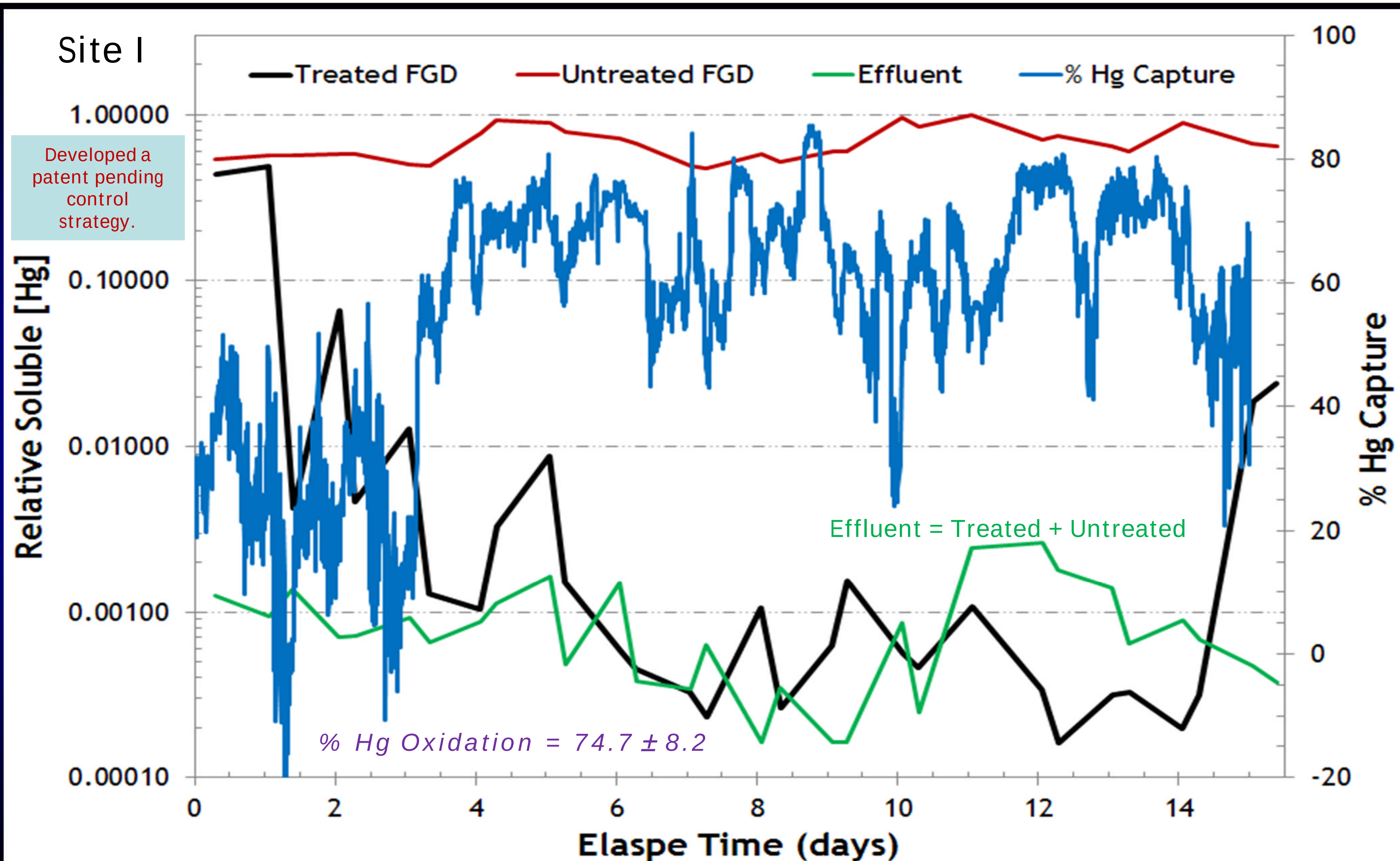
Site II: Summary of Performance

Comparison	Elapse (Hrs)	Percent			
		Oxidation	Re-emission	Capture	wFGD Efficiency
Baseline	0-5	90.8 ± 3.3	99.4 ± 35.7	-27.6 ± 29.1	-30.9 ± 33.7
MerControl 8034	10-13.5	90.0 ± 2.4	11.3 ± 31.2	88.2 ± 3.2	98.0 ± 2.9
No additive	18-end	93.0 ± 0.4	30.9 ± 1.9	38.7 ± 4.4	41.6 ± 4.7

MerControl 8034 Technology resulted in:

- Hg re-emission was near *zero;*
- Hg capture was equal to Hg oxidation and;
- wFGD efficiency was *greater than 90%*.

Downstream Impact of Increased Capture



Conclusions

- MerControl 8034 patented technology reduces Hg re-emission and increases Hg capture efficiency of wFGDs.
- Technology performance shown across coal, load, and operational changes as well as wFGD types and chemistries.
- Low capital and simple application.
- Reduced Hg emissions without increased wastewater discharge mercury levels is possible.*

*See Keiser, et al, EUEC 2012.

Acknowledgements

James Michels, Alyison Leigh, and Gerald Hunt of Nalco Air Protection Technologies Group.

Demonstration Site Personnel.

Apogee Scientific, Inc. for mercury measurements.