

# Evaluation of Mercury Emissions from Coal-Fired Facilities with SCR-FGD Systems

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# Outline

- **Background**
- **Objectives**
- **Scope of Work**
- **Project Schedule**
- **Results**



# Background

- EPA issued a regulatory determination to control mercury emissions from utility boilers
- EPA assumed that FGD processes removed 80% of inlet mercury
- EPA assumed that SCR-FGD combinations removed 95% of inlet mercury
- SCR catalyst degradation and low-load operation were not considered



# Background

- CONSOL (with co-funding from DOE OCDO, ICCI, and others) measured  $67\pm 6\%$  average mercury removal by ESP-FGD combinations in six units firing bituminous coals
- Additional data are needed to provide a sound basis for considering the efficacy and cost of mercury control



# Objectives

- Evaluating the effects of:
  - SCR on mercury capture in the ESP-FGD combination
  - SCR catalyst degradation on mercury capture
  - low-load operation on mercury capture in an SCR-FGD system
- Collecting data to provide insights into:
  - the nature of mercury chemistry in flue gas
  - the effect of SCR systems on Hg speciation
  - the capture of mercury by different FGD technologies



# Scope Of Work

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- Evaluate the mercury removal co-benefits achieved by the SCR-FGD combination at 11 sites:
  - 3 sites with SCR / SDA / Baghouse
  - 4 sites with SCR / ESP/ wet lime FGD
  - 3 sites with SCR / ESP / wet limestone FGD
  - 1 site with ESP / wet limestone FGD



# Project Schedule

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- Funding
  - October 1, 2002 to December 31, 2004
- Testing
  - 5 sites in 2003 and 6 sites in 2004



# Host Site Information

Site	MW	Air Pollution Control Devices	Coal	Ozone Unit
1	330	SCR / Spray dryer / Baghouse	Bit	year round
2	130	SCR / Spray dryer / Baghouse	Bit	year round
3	550	SCR / Spray dryer / Baghouse	Sub	year round
4	1,300	SCR / ESP/ wet Lime FGD, natural oxidation	Bit	yes
5	460	SCR / ESP/ wet Limestone FGD, natural oxidation	Bit	year round
5a	460	ESP/ wet Limestone FGD, natural oxidation	Bit	N/A
6	1,300	SCR / ESP / LSFO-gypsum wet FGD	Bit	yes
7	684	SCR / ESP / wet Lime - gypsum FGD, ex-situ oxidation	Bit	yes
8	509.5	SCR / ESP/ wet Limestone FGD, inhibited oxidation	Bit	yes
9	184.5	SCR / ESP/ wet Lime FGD, natural oxidation	Bit	yes
10	640	SCR / ESP/ wet Lime FGD, natural oxidation	Bit	yes





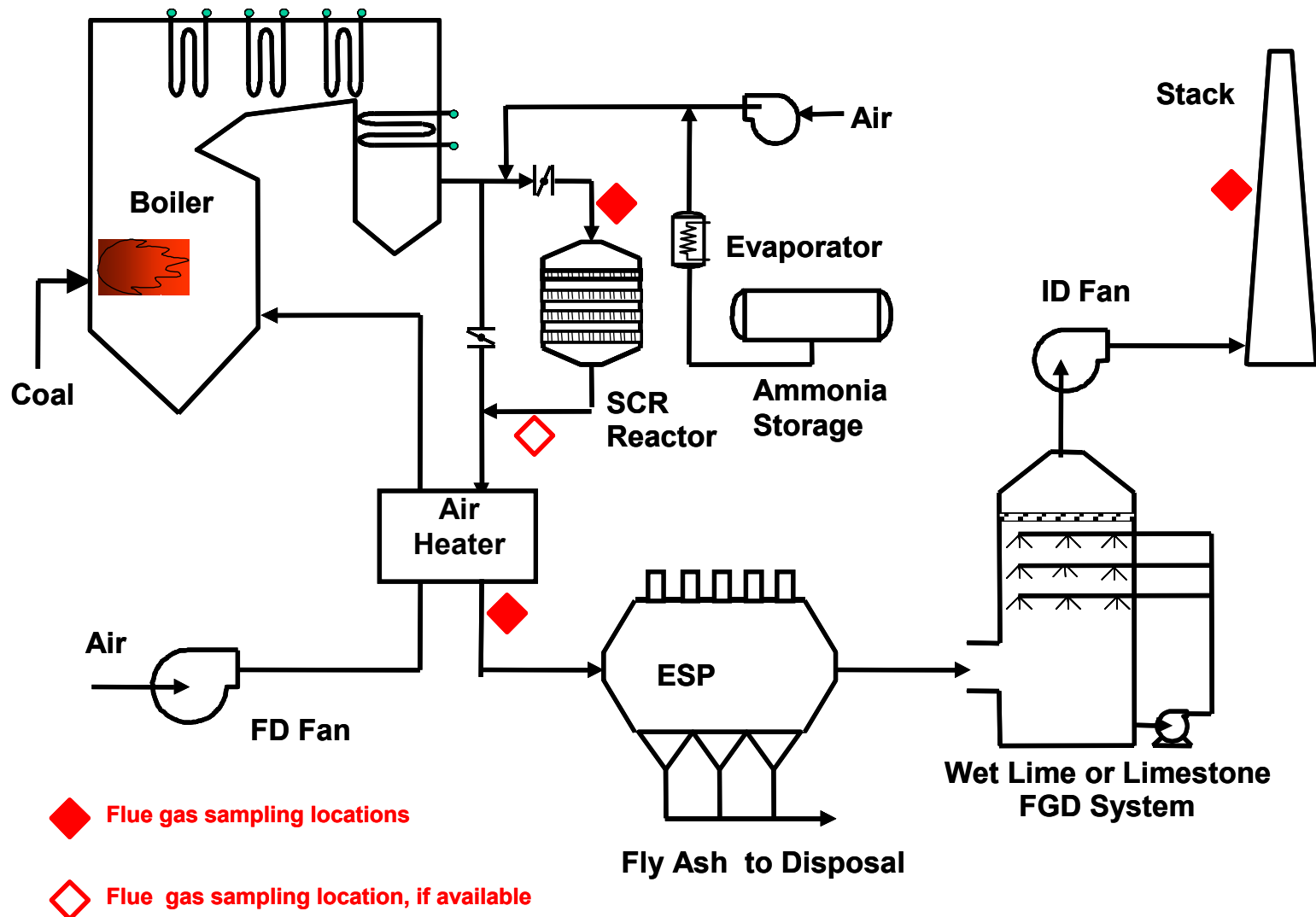
# Sampling Locations

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- Flue gas
  - SCR inlet
  - SCR outlet (if ports are available)
  - Air pre-heater outlet
  - Stack
- Solids
  - Coal
  - Bottom ash
  - Spray dryer hopper ash or ESP hopper ash
  - Scrubber sludge
  - FGD reagent (lime, limestone)



# Sampling Locations for SCR/ESP/FGD Systems



# QA/QC

- Duplicate analysis of all process stream samples and mercury impinger samples (+/- 20%)
- Field blank and reagent blank analyses
- Spike sample recovery determination on 20% of the impinger samples (+/- 30%)
- NIST SRM (+/- 10%)
- Mercury mass balance (+/- 30%)



# Progress as of Today

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- Pre-sampling visits to 6 sites
- Sampling completed at 2 sites with SCR / SDA / Baghouse



# Results

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# Site #1 - % Isokinetic Factor

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Test No.	SCR Inlet	Air Preheater Outlet	Stack
1	98	105	104
2	97	99	101
3	96	101	101
4	93	96	99



# Site # 1 - Coal Analyses

(Units are % dry basis, unless noted otherwise)

	Average	Standard Deviation	PRSD
Carbon	75.1	0.7	1.0
Volatile Matter	36.6	1.0	2.6
Ash	10.1	0.9	8.4
Sulfur	1.0	0.2	15.3
Hydrogen	4.9	0.1	2.1
Nitrogen	1.6	0.1	3.9
Oxygen	7.2	0.2	2.8
Chlorine	0.10	0.02	22.0
Mercury [ppm]	0.09	0.02	18.1
Moisture (as determined)	2.1	0.1	4.7
Heating Value [Btu/lb]	13,391	171.5	1.3



# Site #1 - Flue Gas Hg Speciation at the SCR Inlet

Test Number	Hg Flow Rate, mg/sec			
	Hg <sub>part</sub>	Hg <sup>++</sup>	Hg <sup>o</sup>	Hg <sub>total</sub>
1	0.028	0.95	0.90	1.89
2	0.004	0.95	1.49	2.44
3	0.013	1.06	1.59	2.66
4	0.005	1.11	0.97	2.09
Average	0.013	1.02	1.24	2.27





# Site #1 - Flue Gas Hg Speciation at the Air Heater Outlet

Test Number	Hg Flow Rate, mg/sec			
	Hg <sup>part</sup>	Hg <sup>++</sup>	Hg <sup>0</sup>	Hg <sup>total</sup>
1	0.67	1.20	0.08	1.95
2	0.36	3.07	0.20	3.63
3	0.39	1.68	0.11	2.17
4	0.77	0.72	0.09	1.58
Average	0.55	1.67	0.12	2.33



# Site #1 - Flue Gas Hg Speciation at the Stack

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Test Number	Hg Flow Rate, mg/sec			
	Hg <sup>part</sup>	Hg <sup>++</sup>	Hg <sup>0</sup>	Hg <sup>total</sup>
1	0.002	0.17	0.07	0.24
2	0.001	0.16	0.09	0.24
3	0.001	0.12	0.09	0.21
4	0.005	0.15	0.05	0.20
Average	0.002	0.15	0.08	0.22



# Site #1 - Hg Removal

Test Number	Hg Flowrate (mg/sec)			Coal-Air Preheater Outlet	Coal-to-Stack
	Coal	Air Preheater Outlet	Stack	Hg Material Balance Check (%)	Hg Removal (%)
1	1.33	1.95	0.24	146.6	82.0
2	2.19	3.63	0.24	165.8	89.0
3	1.87	2.17	0.21	116.0	88.8
4	1.89	1.58	0.20	83.6	89.4
Average	1.82	2.33	0.22	128.0	87.3



# Site #2 - % Isokinetic Factor

Test No.	SCR Inlet	Air Preheater Outlet	Stack
1	92	94	98
2	94	96	97
3	98	95	99
4	100	98	100



# Site # 2 - Coal Analyses

(Units are % dry basis, unless noted otherwise)

	Average	Standard Deviation	PRSD
Carbon	77.86	0.04	0.1
Volatile Matter	37.95	0.11	0.3
Ash	7.21	0.14	1.9
Sulfur	1.89	0.04	2.1
Hydrogen	4.85	0.01	0.2
Nitrogen	1.53	0.02	1.3
Oxygen	6.67	0.15	2.2
Chlorine	0.10	0.00	4.0
Mercury [ppm]	0.11	0.01	4.9
Moisture (as determined)	2.11	0.08	3.8
Heating Value [Btu/lb]	14,002	23.04	0.2



# Site #2 - Flue Gas Hg Speciation at the SCR Inlet

Test Number	Hg Flowrate, mg/sec			
	Hg <sup>part</sup>	Hg <sup>++</sup>	Hg <sup>0</sup>	Hg <sup>total</sup>
1	0.006	0.55	1.66	2.22
2	0.007	0.12	1.81	1.93
3	0.011	0.26	1.43	1.70
4	0.007	0.48	1.63	2.11
Average	0.008	0.35	1.63	1.99



# Site #2 - Flue Gas Hg Speciation at the Air Heater Outlet

Test Number	Hg Flowrate, mg/sec			
	Hg <sup>part</sup>	Hg <sup>++</sup>	Hg <sup>0</sup>	Hg <sup>total</sup>
1	0.10	1.60	0.09	1.78
2	0.03	1.38	0.04	1.44
3	0.16	1.24	0.04	1.44
4	0.31	1.24	0.04	1.58
Average	0.15	1.36	0.05	1.56



# Site #2 - Flue Gas Hg Speciation at the Stack

Test Number	Hg Flowrate, mg/sec			
	Hg <sup>part</sup>	Hg <sup>++</sup>	Hg <sup>0</sup>	Hg <sup>total</sup>
1	0.003	0.06	0.03	0.10
2	0.003	0.06	0.03	0.10
3	0.003	0.06	0.03	0.10
4	0.004	0.06	0.03	0.09
Average	0.003	0.06	0.03	0.10



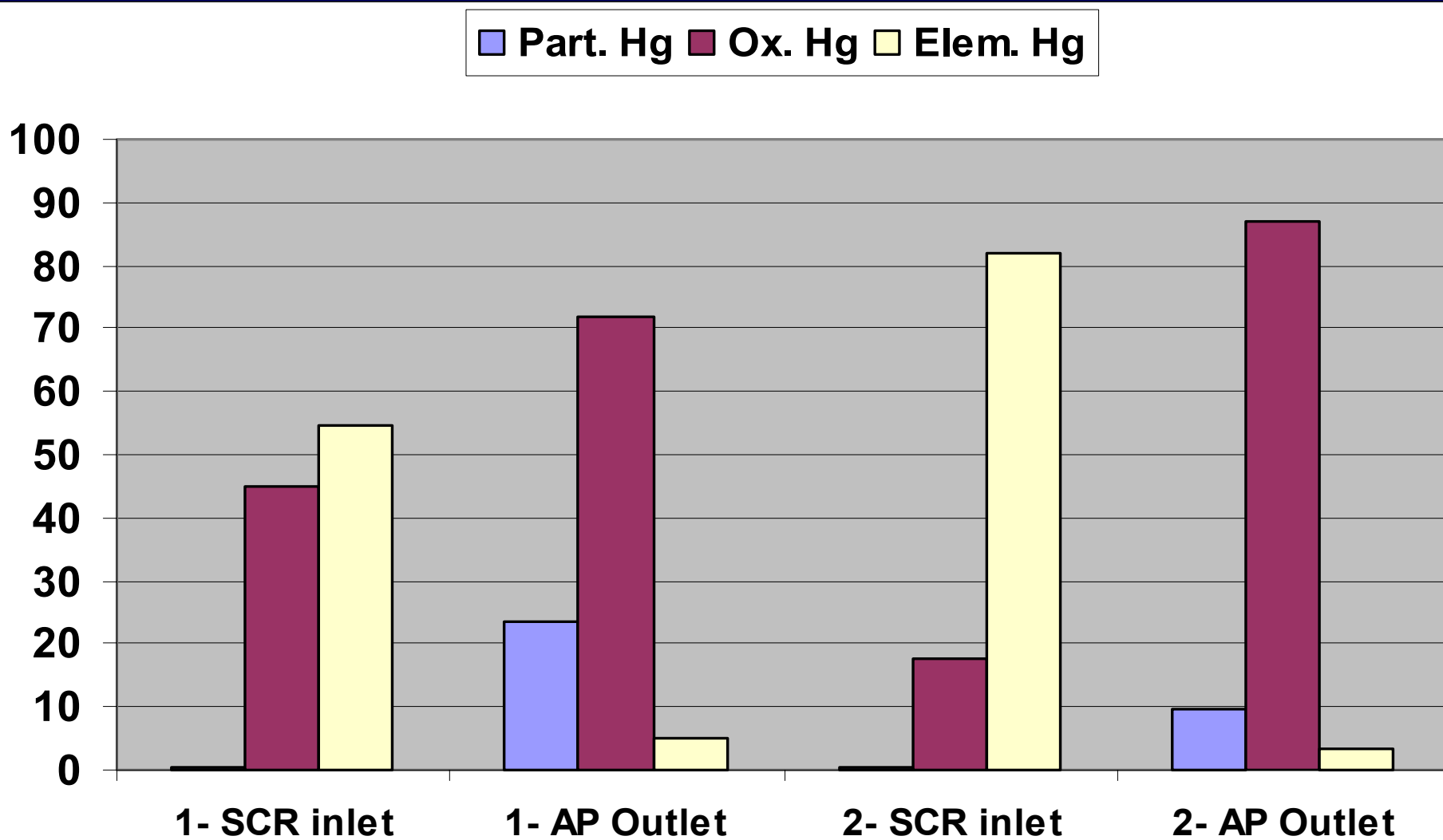


# Site #2 - Hg Removal

Test Number	Hg Flowrate (mg/sec)			Coal-Air Preheater Outlet	Coal-to-stack
	Coal	Air Preheater Outlet	Stack	Hg Material Balance Check (%)	Hg Removal (%)
1	1.73	1.78	0.09	103.8	94.8
2	1.68	1.44	0.09	85.8	94.6
3	1.61	1.44	0.10	89.7	93.8
4	1.65	1.58	0.09	95.6	94.5
Average	1.67	1.56	0.09	93.7	94.5



# Distribution of Hg Species (%)



# Conclusions

- 11 sites were selected to evaluate Hg emissions.
- Tests were conducted at 2 sites with SCR/SDA/Baghouse
- On a coal-feed basis, Hg removals were 87.3% and 94.5%, for Sites 1 and 2, respectively.
- Low load operation could potentially impact mercury speciation and its removal.



# Acknowledgement

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