First-Year Operating Experience from the Greenidge Multi-Pollutant Control Project

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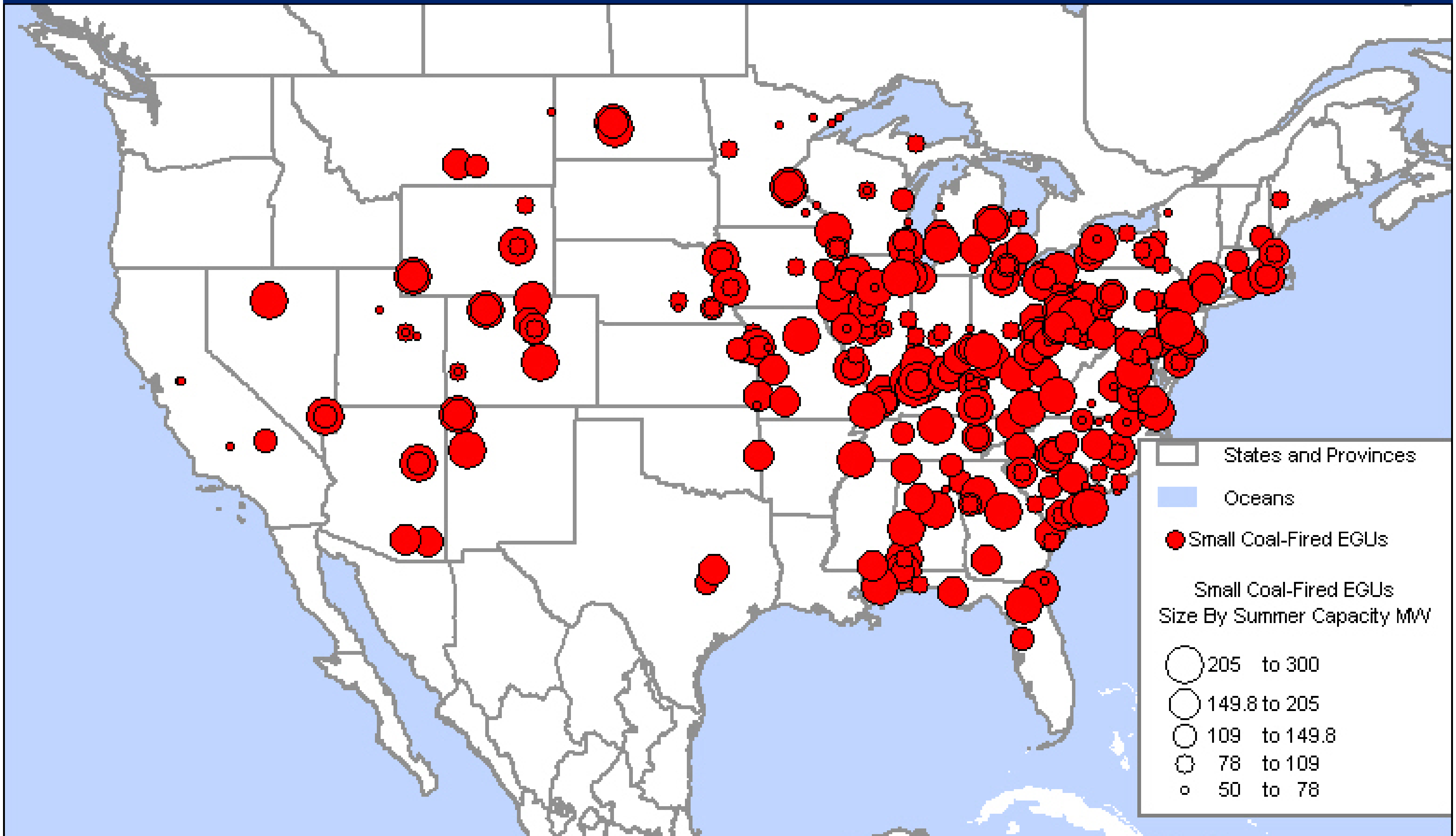
Greenidge Multi-Pollutant Control Project

- Part of U.S. DOE's Power Plant Improvement Initiative
- Participants
  - CONSOL Energy Inc. (administration, testing, reporting)
  - AES Greenidge LLC (host site, operations)
  - Babcock Power Environmental Inc. (EPC contractor)
- Funding
  - U.S. Department of Energy, National Energy Technology Laboratory
  - AES Greenidge LLC
- Goal: Demonstrate a multi-pollutant control system that can cost-effectively reduce emissions of NO_x, SO_2, mercury, acid gases (SO_3, HCl, HF), and particulate matter from smaller coal-fired EGUs

Existing U.S. Coal-Fired EGUs

50-300 MW_e



Existing U.S. Coal-Fired EGUs
50-300 MW_e

- ~ 420 units not equipped with FGD, SCR, or Hg control
  - Represent almost 60 GW of installed capacity
  - Greater than 80% are located east of the Mississippi River
  - Most have not announced plans to retrofit
- Difficult to retrofit for deep emission reductions
  - Large capital costs
  - Space limitations
- Increasingly vulnerable to retirement or fuel switching because of progressively more stringent environmental regulations
  - CAIR, CAVR, state regulations, possible Hg MACT
- Need to commercialize technologies designed to meet the environmental compliance requirements of these units

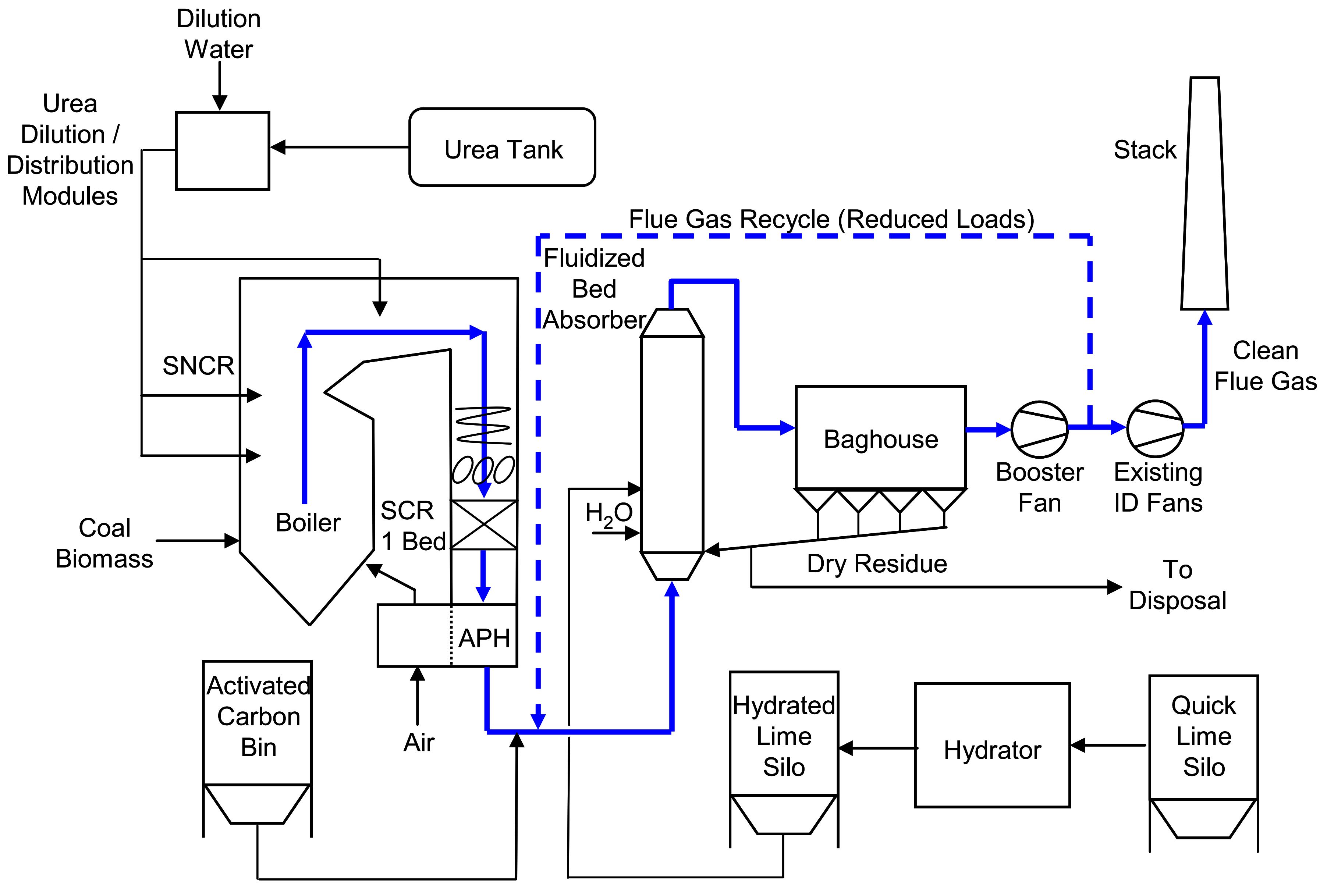
AES Greenidge Unit 4
(Boiler 6)

- Dresden, NY
- Commissioned in 1953
- 107 MW_e (EIA net winter capacity)
- Reheat unit
- Boiler:
  - Combustion Engineering tangentially-fired, balanced draft
  - 780,000 lb/h steam flow at 1465 psig and 1005 ^oF
- Fuel:
  - Eastern U.S. bituminous coal
  - Biomass (waste wood) – up to 10% heat input
- Existing emission controls:
  - Overfire air (natural gas reburn not in use)
  - ESP
  - No FGD – mid/high-sulfur coal to meet permit limit of 3.8 lb SO_2/MMBtu

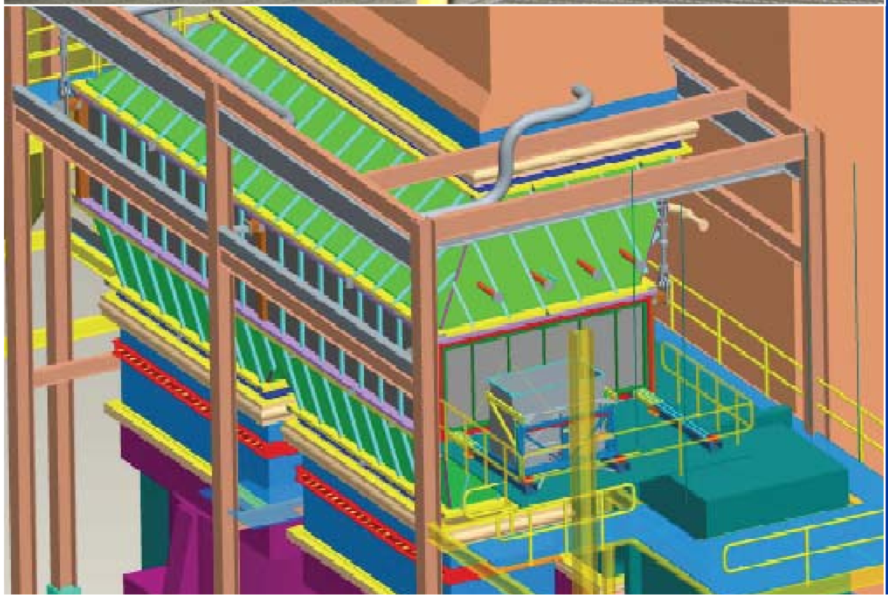
Design Objectives

- Deep emission reductions
- Low capital costs
- Small space requirements
- Applicability to high-sulfur coals
- Low maintenance requirements
- Operational flexibility

Process Flow Diagram

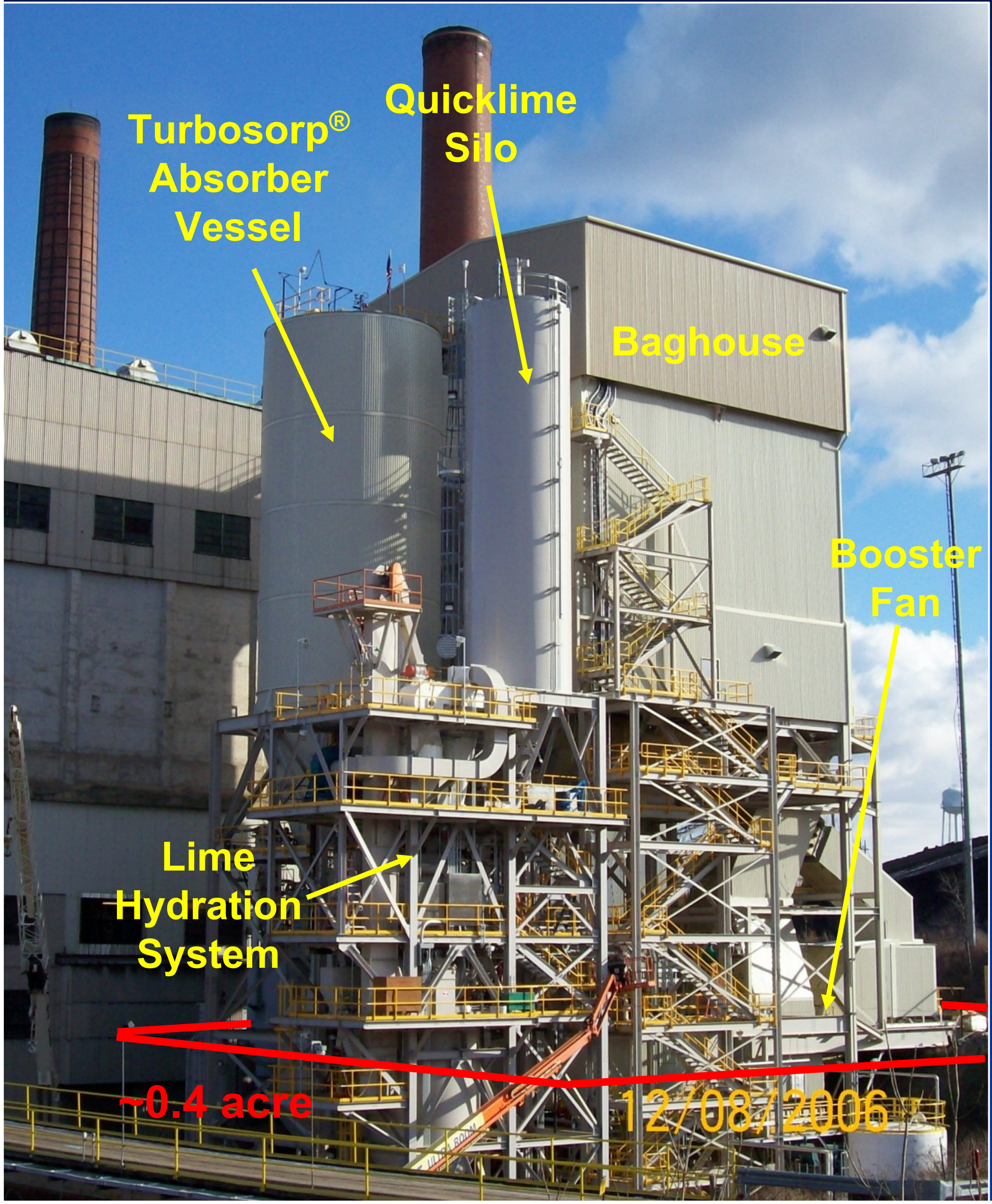


Hybrid NO_x Control System



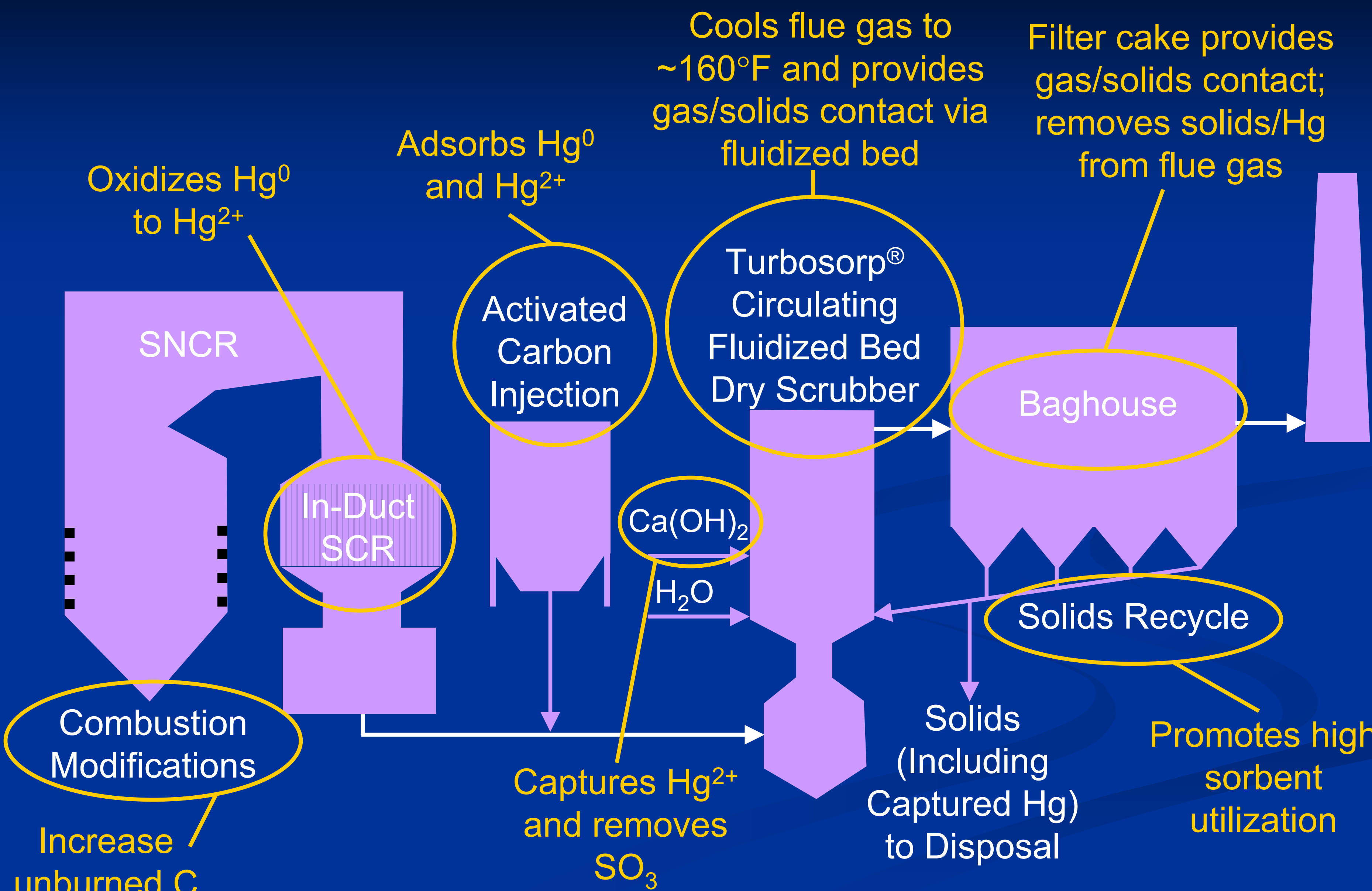
- Combustion Modifications
  - Low-NO_x burners, SOFA
  - Reduce NO_x to 0.25 lb/mmBtu
- SNCR
  - Three zones of urea injection
  - Provide NH_3 slip for SCR (NO_xOUT CASCADE®)
  - Reduce NO_x by ~ 42.5% (to 0.14 lb/mmBtu)
- SCR
  - Single catalyst bed (1.3 m)
  - Cross section = 45’ x 14’
  - Fed by NH_3 slip from SNCR
  - Reduce NO_x by ≥ 30% (to ≤ 0.10 lb/mmBtu)

Turbosorp® System



- Completely dry
- Separate control of hydrated lime, water, and recycled solids injection
- High solids recirculation
- Small footprint
- Carbon steel construction
- No wet stack
- Few moving parts
- Projected Ca/S is 1.6-1.7 mol/mol for design fuel

Design Features for Mercury Control



Hg Reduction Target: ≥ 90% (coal-to-stack)

Guarantee Tests

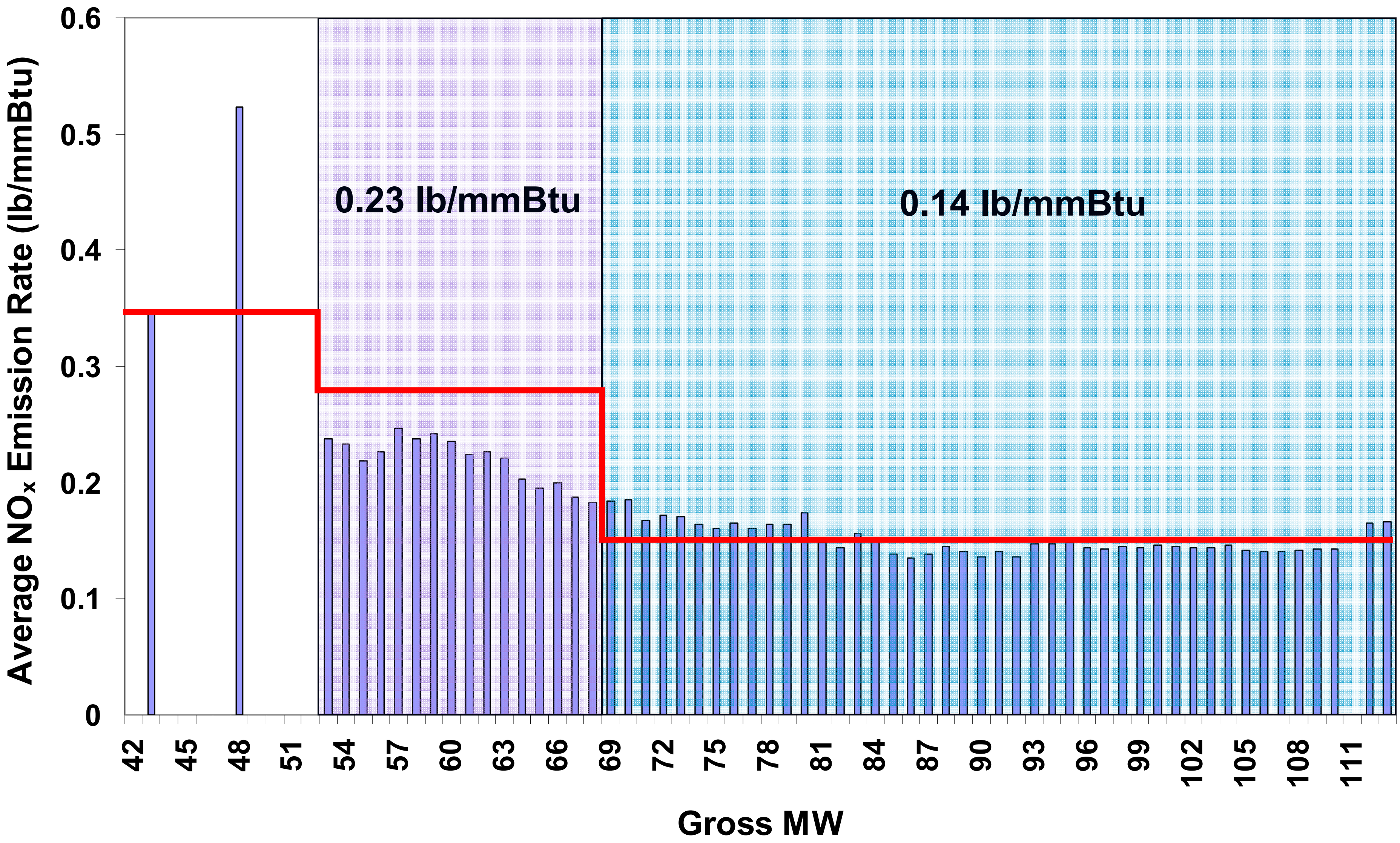
Full Load, 2.4-3.2% Sulfur Eastern U.S. Bituminous Coal
March-May 2007

Parameter	Performance Target	Measured Performance
NO_x emission rate	≤ 0.10 lb/mmBtu	0.10 lb/mmBtu*
SO_2 removal	≥ 95%	96%
Hg removal	≥ 90%	
Without ACI		≥95%
With ACI		≥94%
SO_3 removal	≥ 95%	97%
HCl removal	≥ 95%	97%
HF removal	≥ 95%	Indeterminate

* Performance of hybrid NO_x control system has been affected by large particle ash and ammonia slip. Plant typically operates at 0.10-0.15 lb/mmBtu to maintain acceptable combustion characteristics.

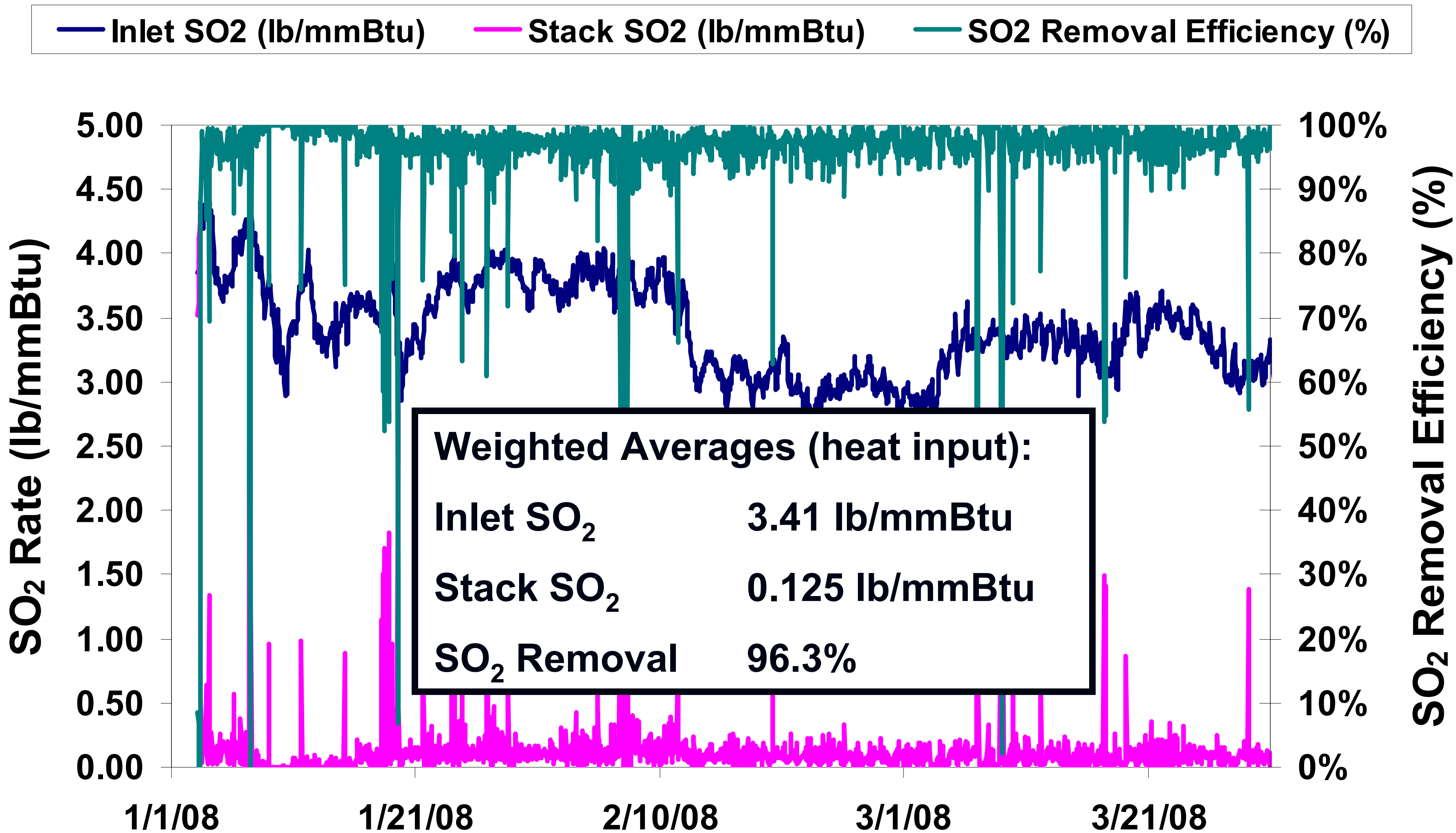
NO_x Emissions vs. Load

January - March 2008



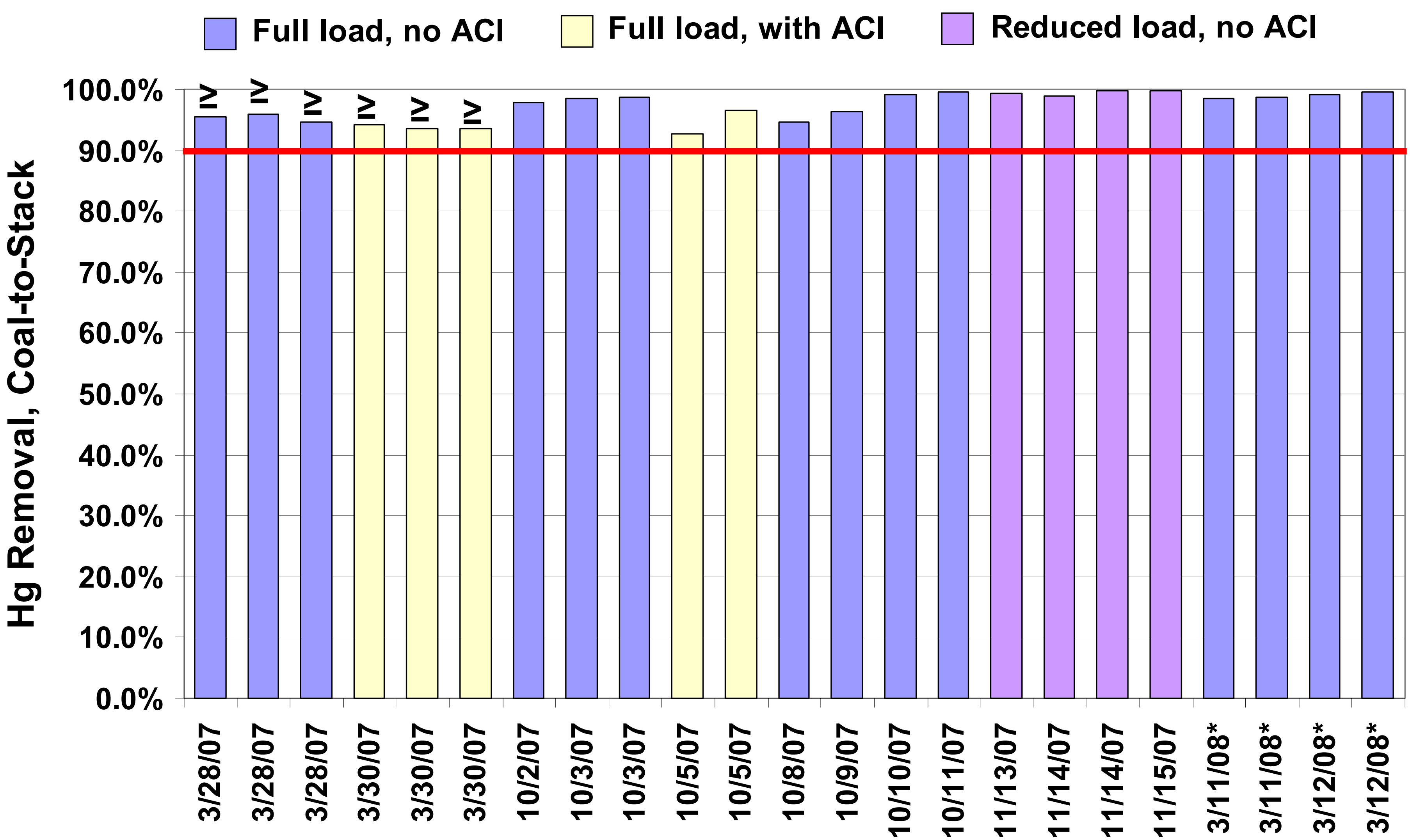
SO_2 Removal Performance

January – March 2008



Hg Testing Results

Ontario Hydro Method



* Preliminary result

Acid Gas Testing Results

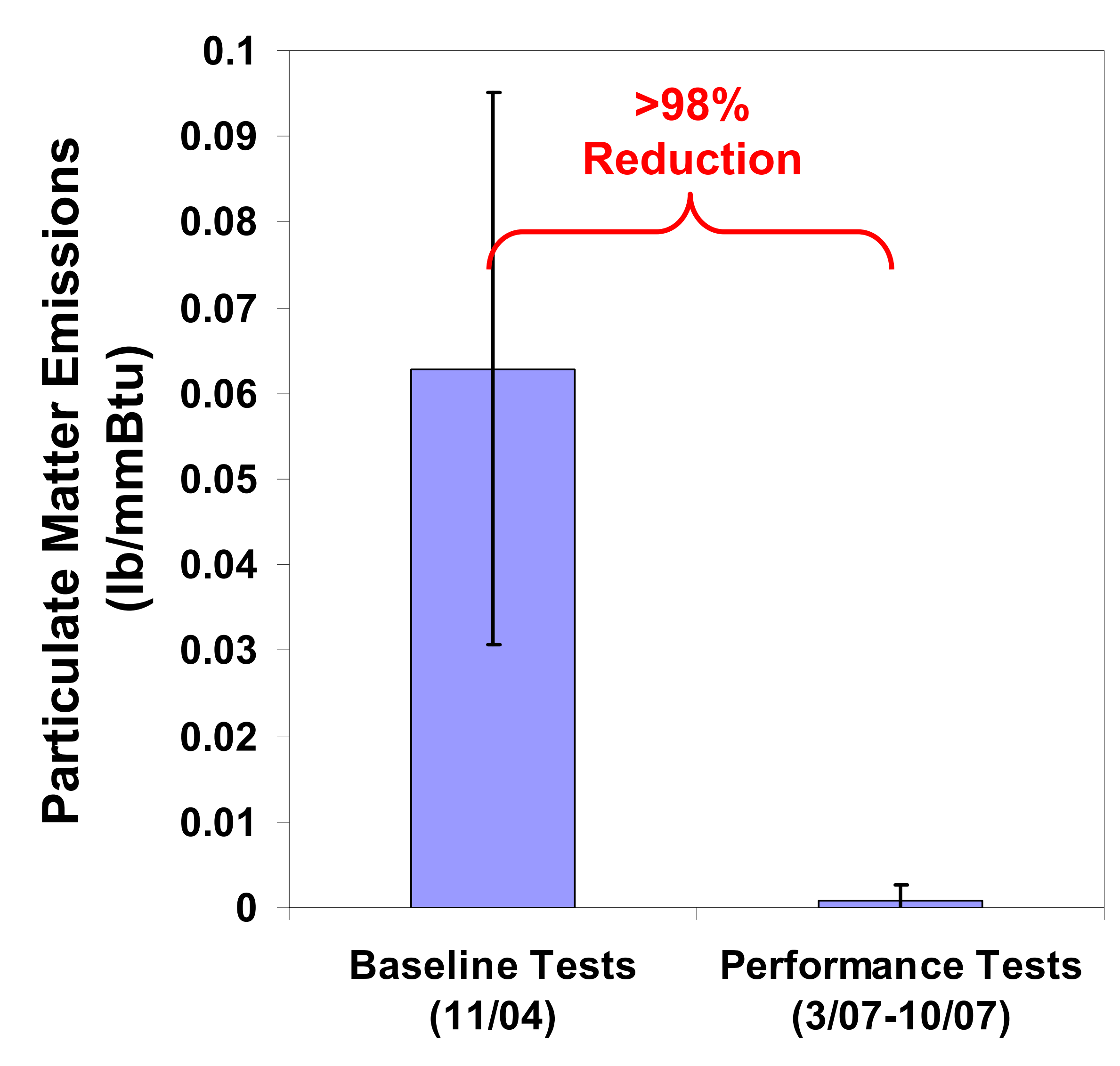
March 2007 – March 2008

	No. of Tests	Scrubber Inlet, ppmvd @ 3% O_2	Stack, ppmvd @ 3% O_2	Removal Efficiency, %
SO_3	21	11.8 (4.7 - 28.7)	0.7 (0.2 - 1.7)	92.1 (78.8 - 97.4)
HCl	13	38.0 (29.0 - 48.6)	1.4 (0.3 - 2.8)	96.2 (92.2 - 99.1)
HF[a]	9	1.45 (0.87 - 2.07)	<0.17 (<0.15 - <0.20)	>86.9 (>76.7 - >92.0)

[a]Only includes measurements for which the HF concentration at the Turbosorp® inlet was above the method detection limit. The inlet HF concentration was below the method detection limit for 5 additional tests.

Particulate Testing Results

EPA Method 5/17, Full Load



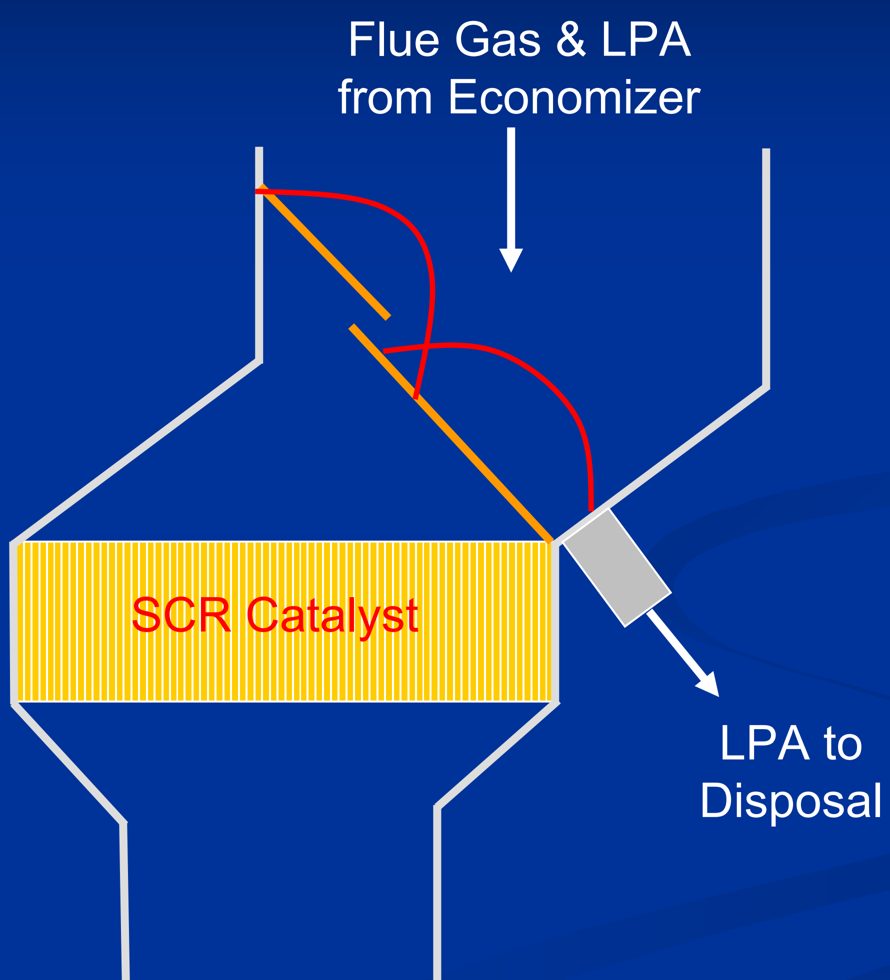
New baghouse significantly reduces particulate matter emissions relative to old ESP, in spite of increased particle loading from Turbosorp® scrubber

Error bars represent ± 1 standard deviation

O&M Experience – Large Particle Ash

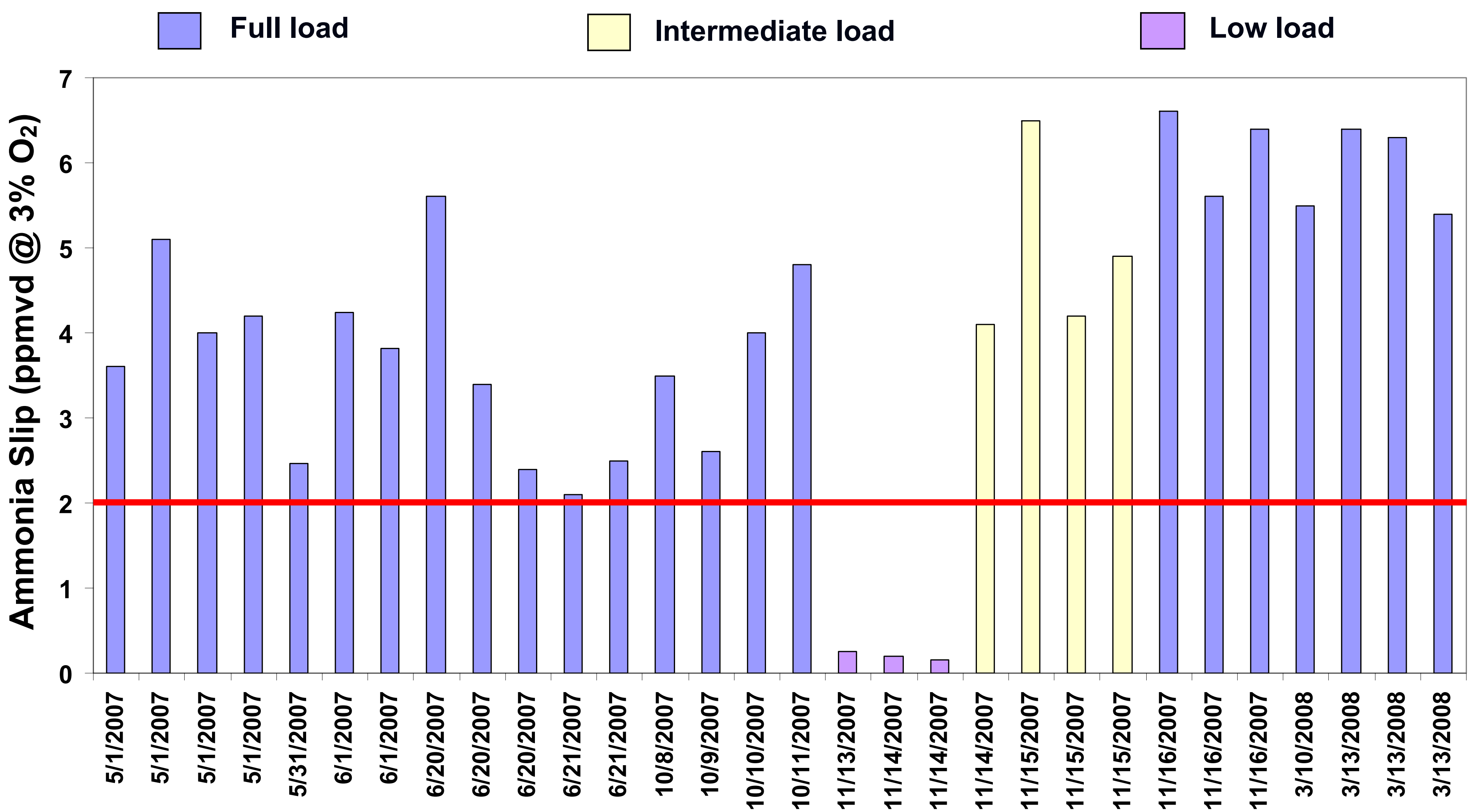
- Decreased NO_x removal efficiency
- Increased urea consumption, ammonia slip
- Increased pressure drop
- Forced outages for catalyst cleaning

O&M Experience – Large Particle Ash
(continued)



O&M Experience – Ammonia Slip

EPA CTM 027, Air Heater Inlet



O&M Experience - Turbosorp® System

- O&M handled by existing plant staff
- Lime hydration system is most maintenance-intensive part
  - Use delivered / stored hydrated lime to allow offline maintenance
  - Most problems involve ball mill and classifier
- Had to add compressed air capacity to satisfy baghouse demand
- Flue gas recycle not used because of problems with reverse flow

- Occasional issues with plugging in the ash recirculation / disposal system
- No condensation issues in the scrubber or baghouse

Economics

AES Greenidge Unit 4 Design Case

Constant 2005 Dollars

	EPC Capital Cost ($/kW)	Fixed & Variable O&M Cost ($/MWh)	Total Levelized Cost
NO_x Control	114	1.25	$3,504 / ton NO_x
SO_2 Control	229	6.14	$567 / ton SO_2

- Variable operating costs for dispatch calculations are about $626 / ton NO_x and $241 / ton SO_2
- Mercury control, acid gas control, and particulate matter control are zero-cost co-benefits

Summary

- Greenidge MPC process uniquely designed to meet the needs of smaller coal-fired units
- EPC capital cost < $350/kW (2005)
- Footprint < 0.5 acre
- Performance of Turbosorp® system has been commendable
- Hybrid NO_x control system has been affected by LPA, ammonia slip, and combustion issues

- Greater than 95% Hg removal achieved with no ACI
- O&M handled by existing plant staff
- Additional testing through summer 2008

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