



# Amended Silicates™ for Removing Mercury from Power Plant Flue Gas

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# Presentation Outline

- ADA Mercury control experience
- Intro to Amended Silicate sorbents
- Lab test results
- Pilot test results on flue gas slipstream
- Status of development project
- Plans for commercial-scale demonstration



# ADA Mercury Control History

- Nine years developing mercury control solutions
- \$9 million in government and industrial funding
- Wide range of technologies conceived, developed, evaluated, commercialized
- Bench-top to pilot-scale systems designed, built, operated in the field



# ADA Mercury Control Technologies Development

Technology	Media		
	Gas	Liquid	Solid
Disposable Sorbent	P,R	C	
Regen. Sorbent	P,R	P,R	
Photocatalyst		P	
Reagent	C		P,C

**R: Current Research and Development Project**

**P: Pilot Demonstration**

**C: Commercial Product**



# Pilot Testing of Activated Carbon for Hg Capture

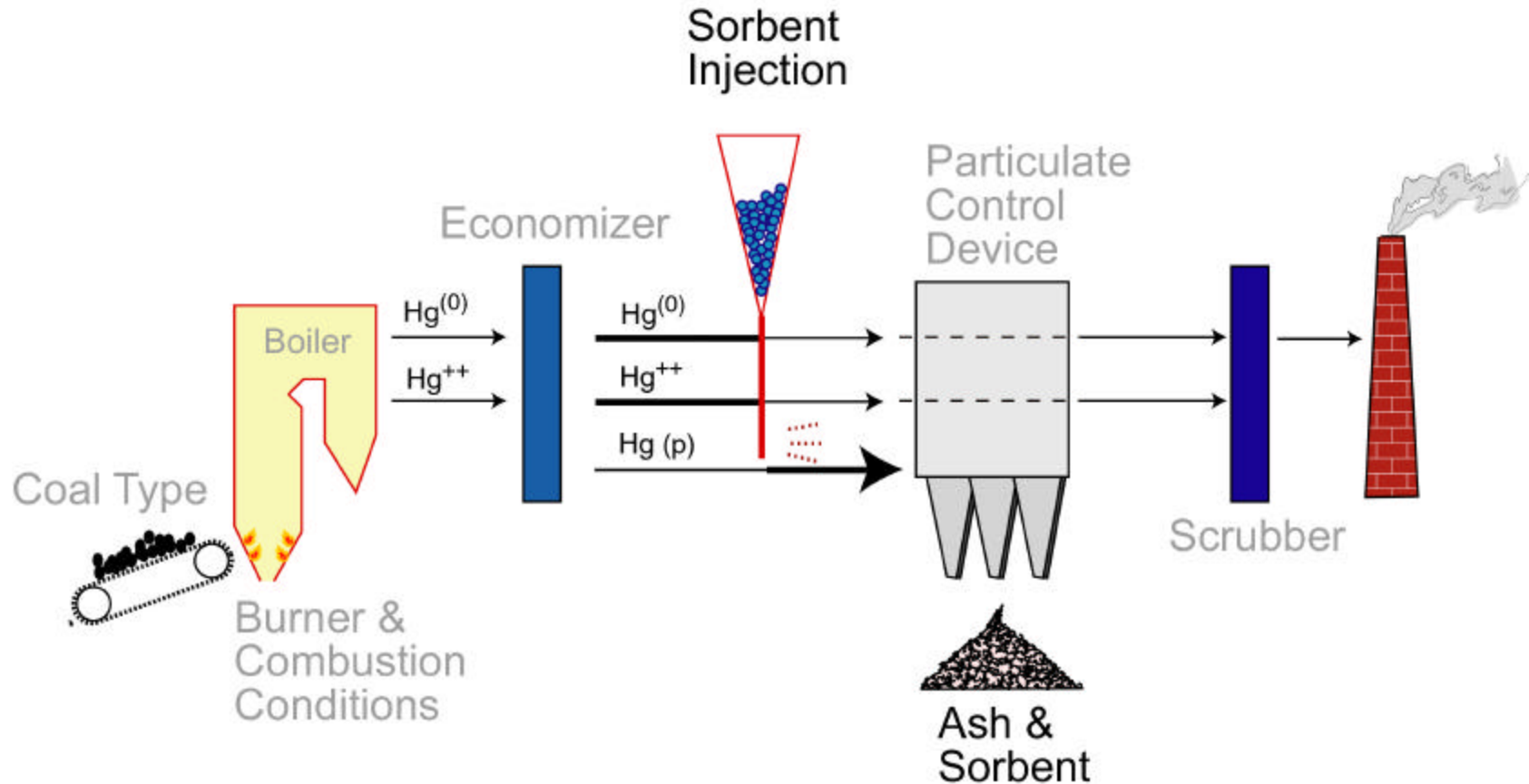
- **Multi-year ADA project funded by DOE**
- **Slipstream pilot unit installed at plant burning PRB coal**
- **Activated carbon injection evaluated in ESP & baghouse configurations**
- **Limitations of activated carbon identified**
- **Stimulated search for alternative sorbents at ADA**



# Features of Sorbents for Mercury Control

- **Low capital cost**
- **Easy to retrofit**
- **Control is simple**
- **Minimal impact on plant operation**
- **Hg removal rate proportional to sorbent injection**
- **Applicable to all coals, some more difficult**
- **Ongoing need for sorbent**
- **Sorbent collected with fly ash**

# Injected Sorbents for Mercury Control



# Amended Silicates™:

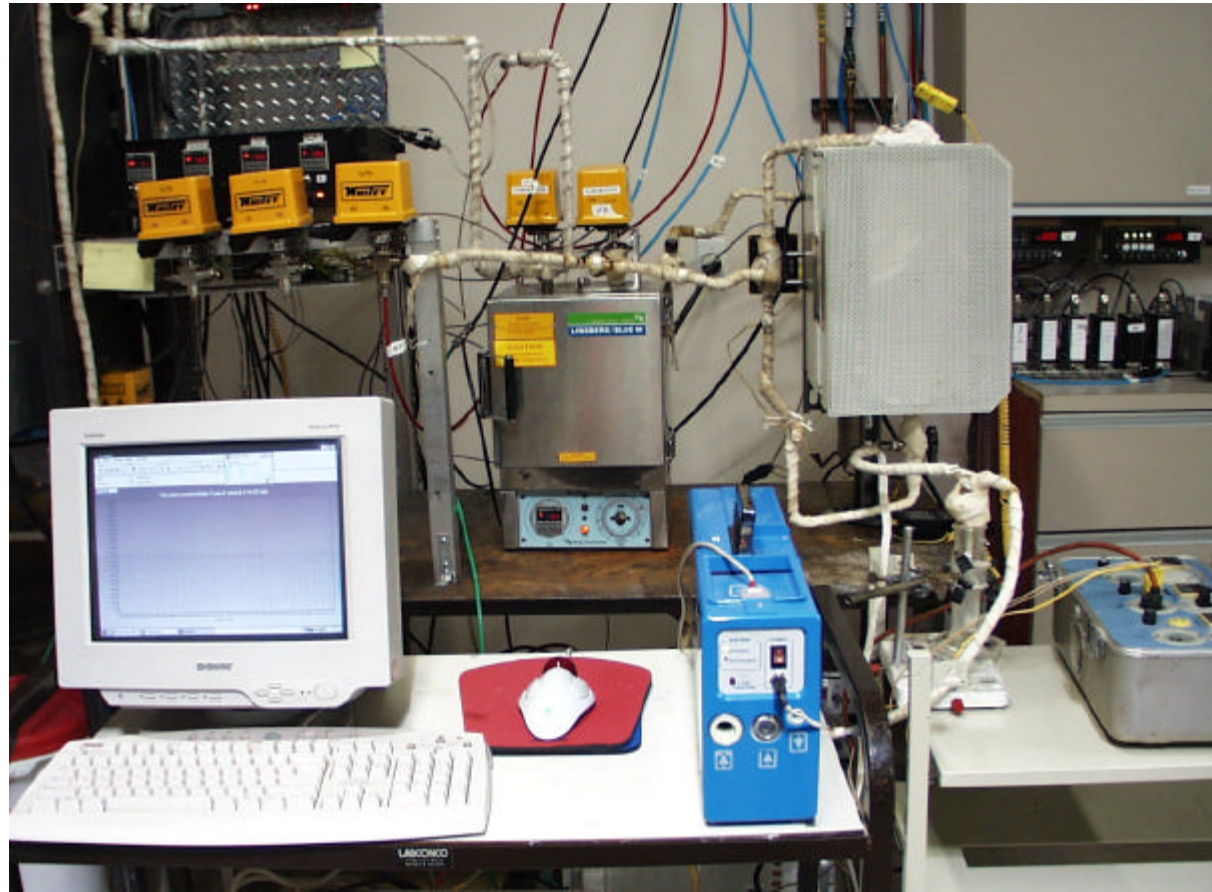
## A new sorbent approach



- Amended Silicates™ are inexpensive, non-carbon substrates amended with mercury-binding sites
- Silicate-based substrate, chemically similar to the native fly ash- no impact on sale of fly ash
- Sites react with elemental *and* oxidized mercury species to bind the mercury to the sorbent
- ADA developing two formulations funded by DOE, EPA (internal competition)
- Patent pending



# Laboratory Tests of Amended Silicate™ Formulations

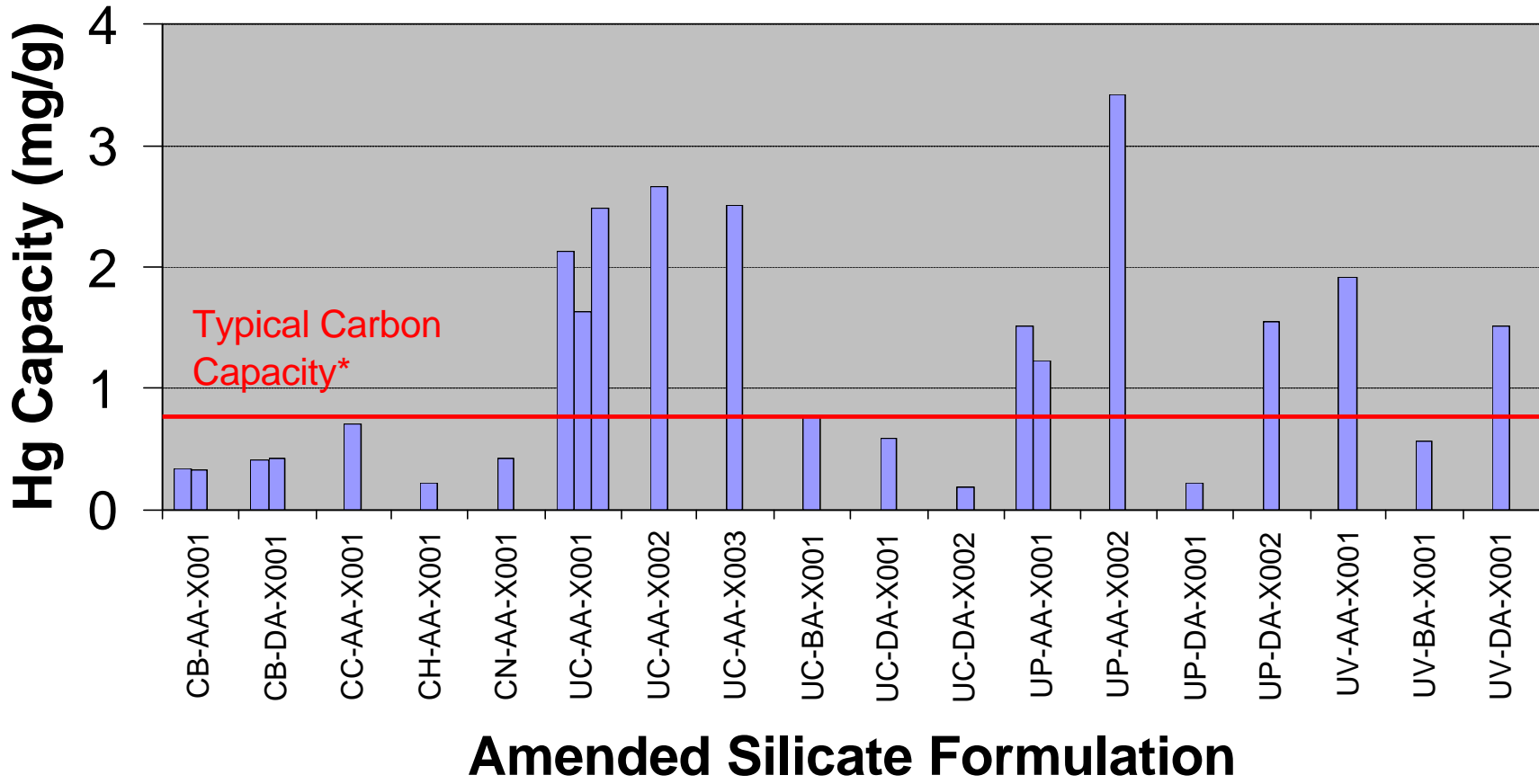




# Simulated Flue Gas Composition for Lab Tests

- **SO<sub>2</sub>: 1,600 ppm**
- **NO<sub>x</sub>: 400 ppm**
- **CO<sub>2</sub>: 12%**
- **N<sub>2</sub>: Balance**
- **Water vapor at 2%**
- **Elemental mercury vapor at 30-80 µg/m<sup>3</sup>**
- **No HCl in majority of tests- better simulation of Lignite flue gas**

# Sorbent Capacity Results





# Lab Test Results

- **Demonstrated mercury capacity of 2-5 times that of activated carbon**
- **No effect of acid gas on performance of Amended Silicate™ sorbents**
- **Captures elemental and oxidized mercury with equal efficiency**
- **Multiple variants carried forward to pilot testing**



# Pilot Plant for ADA AS Sorbent Evaluation

- Operates on slipstream at Xcel Energy Comanche Station
- Unit configured with baghouse for particulate control
- Temperature control of flue gas (heat or cool)
- Several injection ports to study residence time effect
- Mercury measurement upstream and downstream of injection





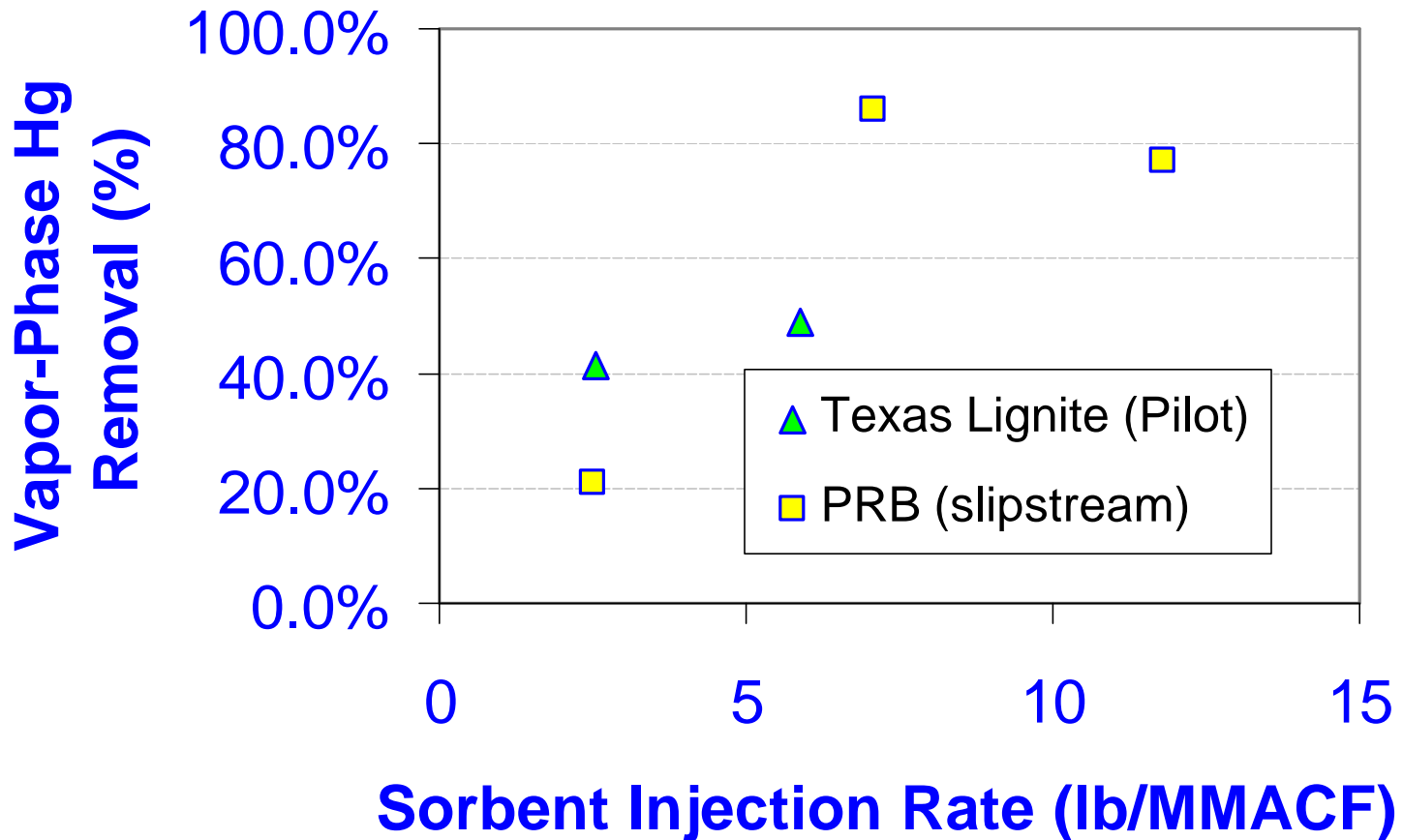
# Initial Pilot Results

	<i>Sorbent Injection Rate (lb/MMACF)</i>		
<i>Msmt. Condition</i>	<b>2.5</b>	<b>7.1</b>	<b>11.8</b>
Total Hg baseline	7.32	4.61	7.55
Baseline Vapor	7.02	3.83	7.03
Pre-Baghouse Hg	5.61	0.52	1.63
Post-Baghouse Hg	3.26	0.46	0.25
<i>% Removal</i>	<i>55.5%</i>	<i>90.0%</i>	<i>96.7%</i>

**Note: Concentration units [ $\mu\text{g}/\text{Nm}^3$ ]**



# In-Flight Hg Removal Rates



**1.4 second contact time (In-Flight) for all tests**



# Amended Silicates™ Impact on Fly Ash Salability

- **Substrate materials are silicates, similar to fly ash composition > Expect no effect on reuse of fly ash**
- **Tested properties of fly ash plus sorbent at Boral**
  - Prepared sample of Arapahoe ash with 0.7% sorbent (equivalent to 5 lb. sorbent/MMACF)
  - Results showed no effect on air entrainment for sorbent plus fly ash sample compared to neat fly ash sample
  - At a lower loading of activated carbon, fly ash was rendered unsalable at other test



# Cost Impact of Lost Fly Ash Sales- 500 MW Plant

	Amended Silicate™	AC with lost fly ash sales
Yearly delivered sorbent	\$3.0 Million	\$3.0 Million
Maint., labor, power	\$0.2 Million	\$0.2 Million
Lost fly ash revenue		\$2.6 Million
Fly ash disposal		\$1.3 Million
Debt Service	\$0.1 Million	\$0.1 Million
Total	\$3.3 Million	\$7.2 Million



# Target Markets

- **Plants that wish to continue to sell collected fly ash plus sorbent**
- **Plants with limited lifetime > low capital investment for mercury control**
- **Plants burning low-chloride coals, especially lignite and PRB**
- **Plants with existing or planned dry scrubbers (spray dryers)**



# Amended Silicate™

## Development Milestones

- ✓ Identified promising sorbent formulations in lab testing- two substrate families
- ✓ Best sorbents now being tested in power plant slip stream (PRB coal)
- ✓ ADA partnered with CH2M Hill for commercialization of technology
- ✓ Optimizing sorbent preparation process
- ☐ Interest in pilot testing in coal-fired flue gas streams
- ☐ Plans for evaluation on a commercial scale



# Commercial-Scale Demonstration Objectives

- **Show capability to make Amended Silicate™ sorbent at ton/day rate**
- **Demonstrate sorbent performance at commercial scale:**
  - Testing at plants that represent target markets
  - Testing on eastern bituminous, lignite and low-sulfur western coals
- **Make quantities of Amended Silicate™ sorbent available for evaluation by interested parties**
- **Build and lead consortium to promote technology and cooperate on testing**



# Summary- Attributes of Amended Silicates™

- **Application via injection as a dry powder: low capital-cost option**
- **Higher Hg-capacity than activated carbon**
- **Not affected by moisture or acid gas components**
- **No impact on the sale of fly ash as a concrete additive**
- **Per-lb sorbent cost equal to activated carbon, with significantly lower cost per lb mercury removed**
- **Performance not affected by low chlorine coals**



# Aknowledgements

- **Development funding from US DOE, US EPA, CH2M Hill**
- **In-Kind contributions from Xcel Energy, Boral Materials Technologies**