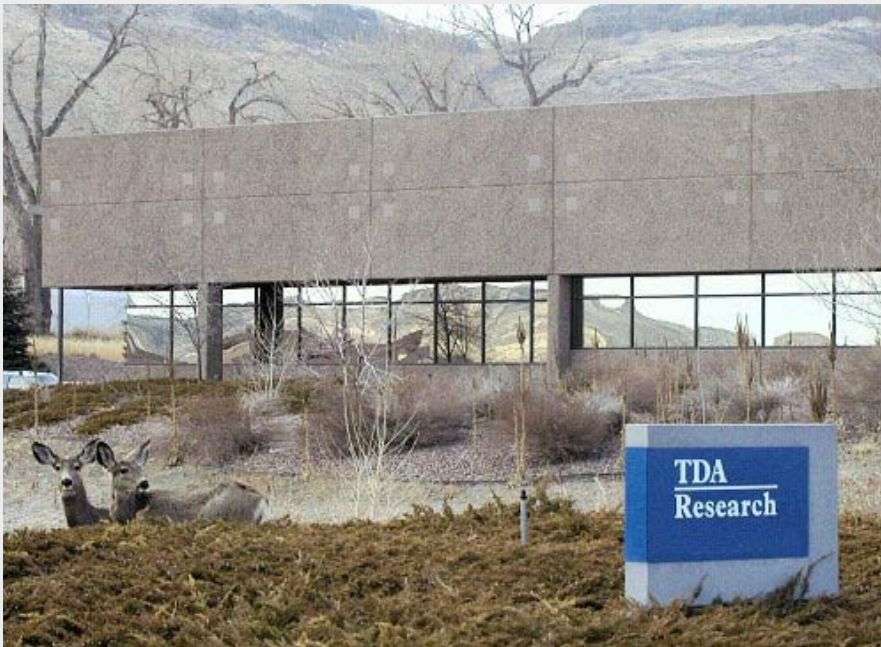


# Low Cost Sorbent for CO<sub>2</sub> Capture on Existing Plants



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**July 9, 2012**

**TDA Research Inc. • Wheat Ridge, CO 80033 • [www.tda.com](http://www.tda.com)**

# Project Overview

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## **PRDA Project DE-NT0005497**

### **Funding - Total Project \$1,373,380**

- DOE: \$1,097,839
- Cost Share: \$276,541

### **Project Performance Dates**

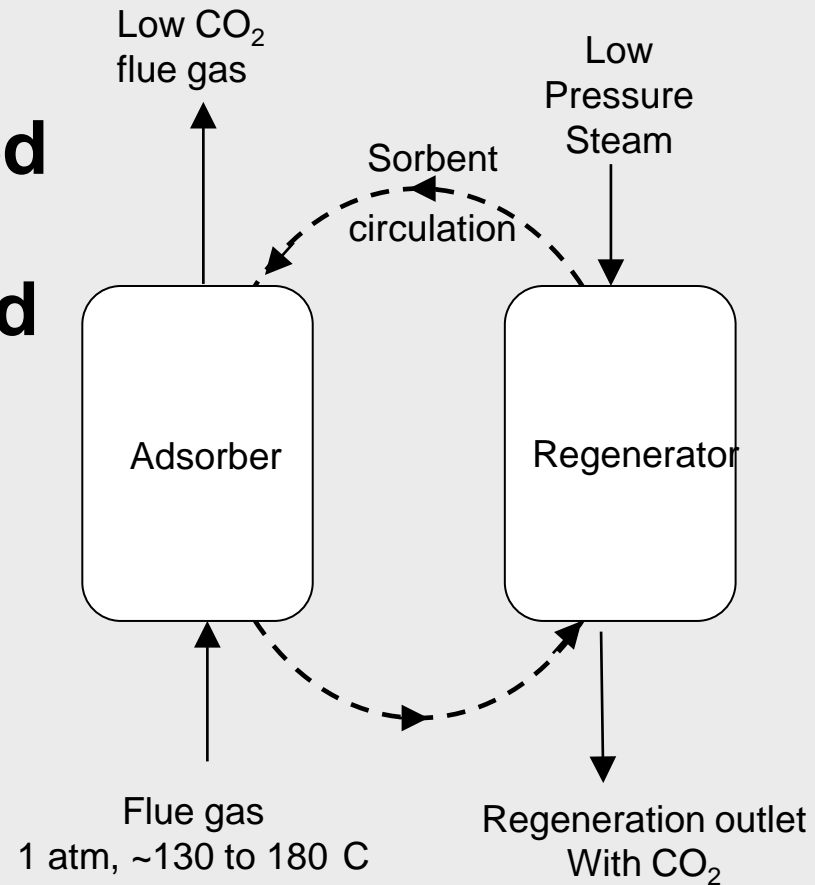
- November 1, 2008 to August 31, 2012

### **Project Partners**

- TDA Research, Inc (TDA)
- Babcock & Wilcox (B&W)
- Louisiana State University (LSU)
- Western Research Institute (WRI)

# TDA's Approach

- **TDA Research, Inc. is developing a solid alkalized alumina adsorbent and a CO<sub>2</sub> capture process based on this sorbent**



# TDA's Post Combustion CO<sub>2</sub> Capture

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- **Process Features**
  - TDA's approach uses an inexpensive sorbent material
  - The sorbent is regenerated with low pressure steam
  - The system operates at near isothermal conditions
  - The process design has counter-current operation to maximize capture rate and loading with the physical adsorbent

# Project Status

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- **Project goal:**

Demonstrate a CO<sub>2</sub> capture system designed around TDA's physical adsorbent

- **Technical Progress:**

- Evaluated sorbent in bench-scale apparatus at TDA with simulated flue gas
- Tested sorbent under varying cycling and process conditions to optimized operation
- Extended cycling at TDA under simulated conditions
- Field testing with real coal derived flue gas at Western Research Institute

# Bench-scale Apparatus

- **Designed to show continuous absorption and regeneration**
  - Apparatus shows continuous low CO<sub>2</sub> concentration in absorber outlet and high concentration in CO<sub>2</sub> in regeneration outlet gas
- **Multiple fixed beds in series apparatus**
  - Simulates counter-flow
    - Bed cycle between adsorption and regeneration functions
    - Gas flows in series across adsorption (or regeneration) beds



# Multiple Fixed Bed Apparatus

Beds 600cc (4.8L total sorbent)

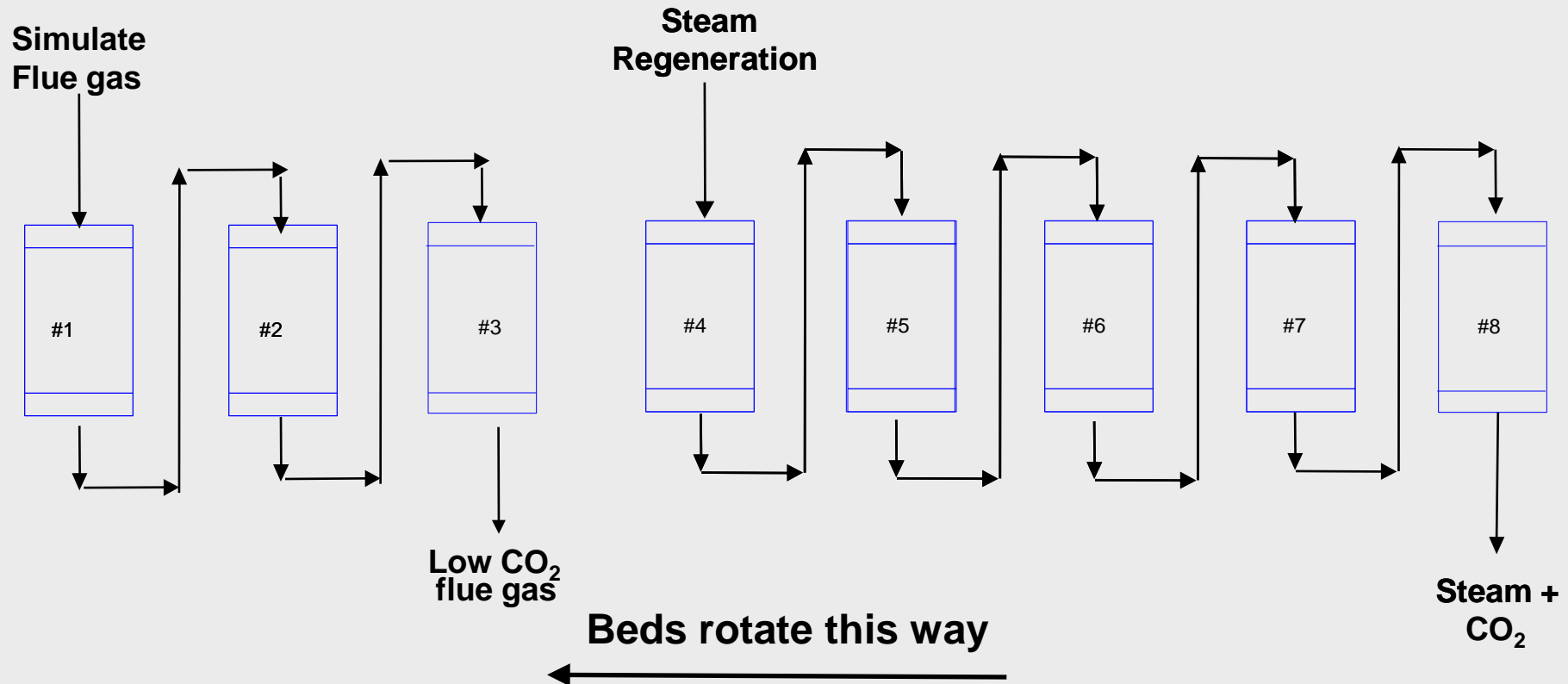


# Series Fixed Bed Apparatus

## 8 Bed System

Adsorption

Regeneration



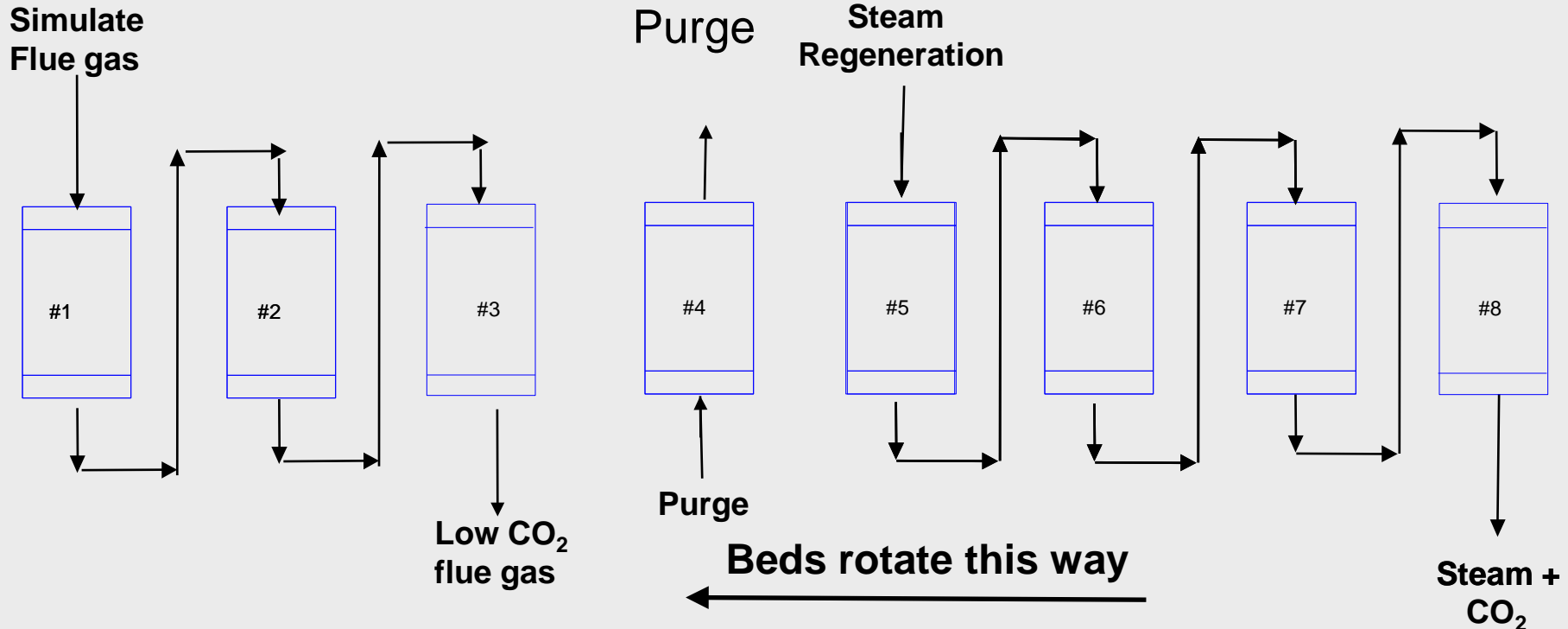


# Series Fixed Bed Apparatus

## 8 Bed System with purge bed

Adsorption

Regeneration



- Purge bed prevents CO<sub>2</sub> from regeneration gas from being carried into flue outlet.
- One bed volume of regeneration gas is displaced out. Then purge gas is pushed back into the adsorber exhaust in the next cycle.

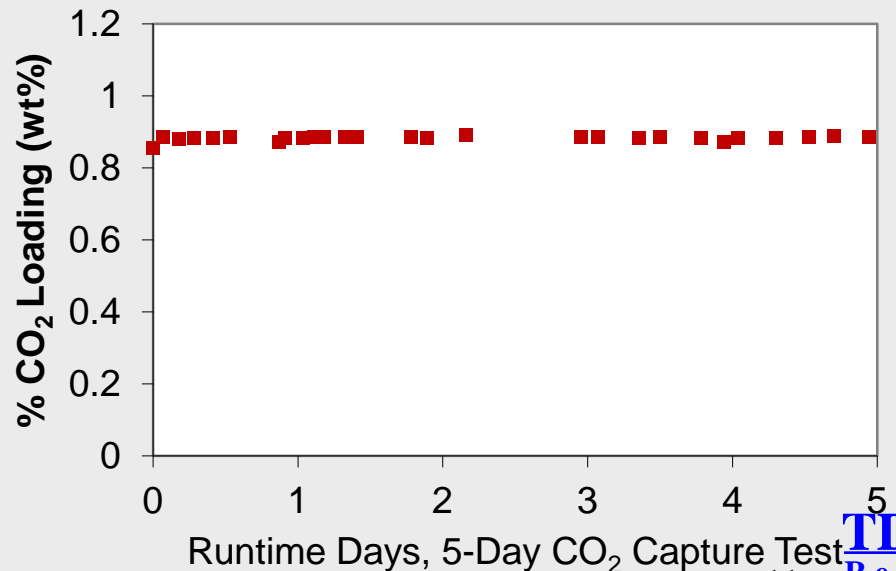
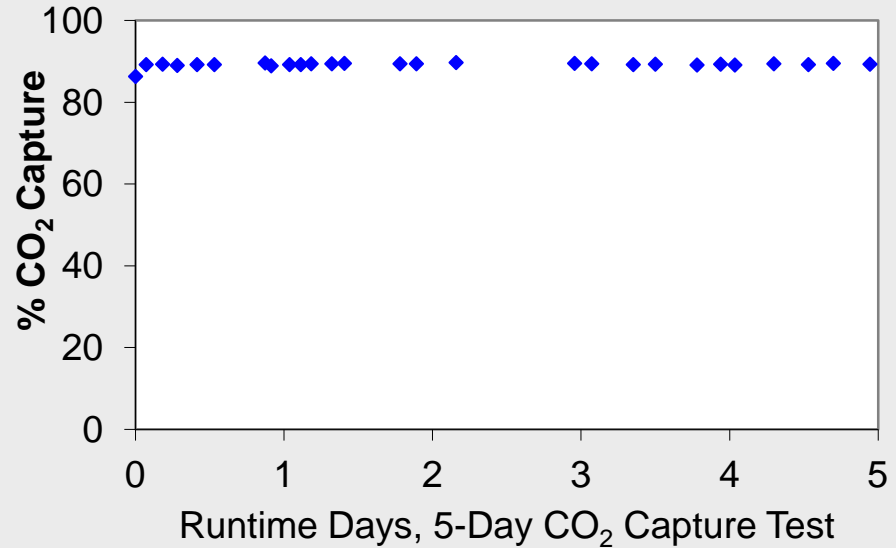
# Results with Purge Bed

- One bed taken off line and made into purge bed
- Compared using 2 adsorption beds, 5 regeneration beds and 1 purge bed vs. 3 adsorption beds, 4 regeneration beds and 1 purge bed
  - Best results with 3 ads beds, 4 reg beds and 1 purge bed
- Purge displaces one bed volume of regeneration gas
- Prevents high level of CO<sub>2</sub> in regeneration bed from being carried over into adsorption side of the system
- Air is used as purge gas
- Adding purge bed improved capture rate by ~10%

# Extended Cycling

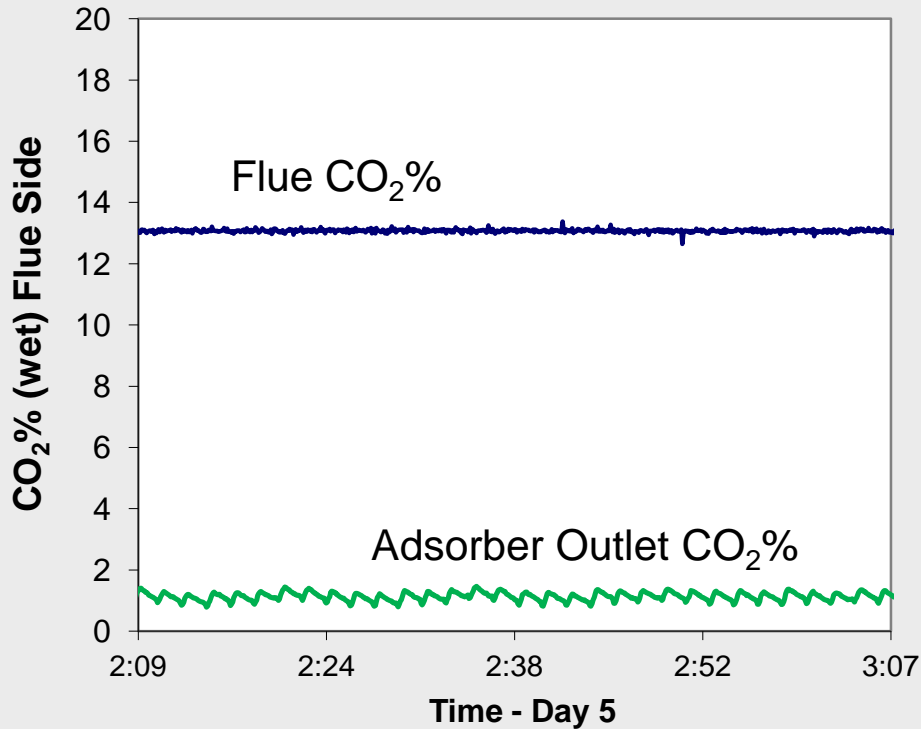
## Bench scale testing at TDA

- Sorbent cycled continuous for 5 days
- Simulated flue
  - 13% CO<sub>2</sub>
  - 6% H<sub>2</sub>O
- Stable performance with CO<sub>2</sub> loading and capture rate
- 89.3% capture achieved
- Sorbent had been previously cycled during testing at TDA over the last year

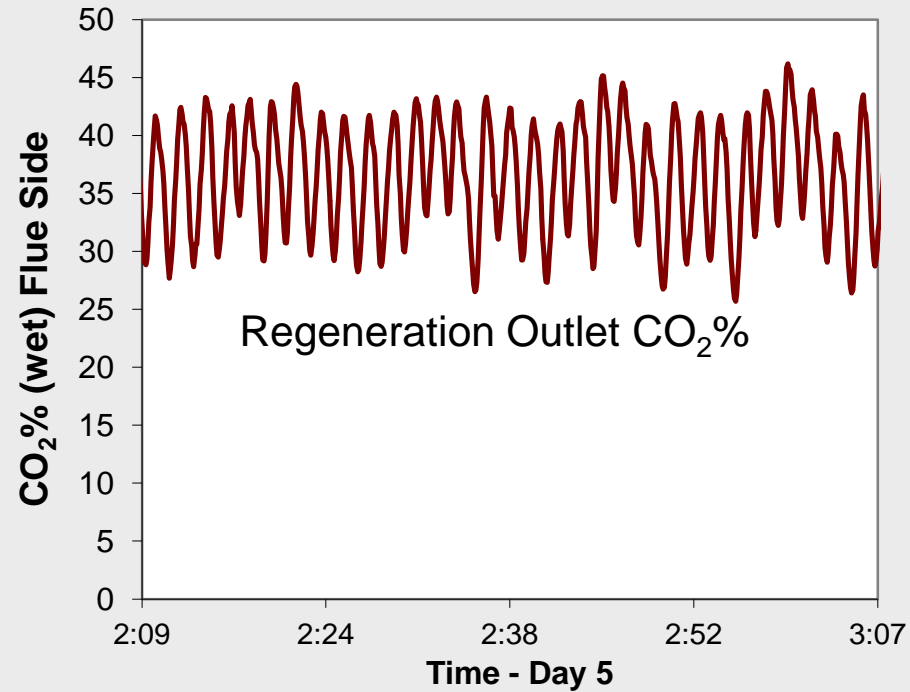


# Extended Cycling at TDA

Flue Gas side



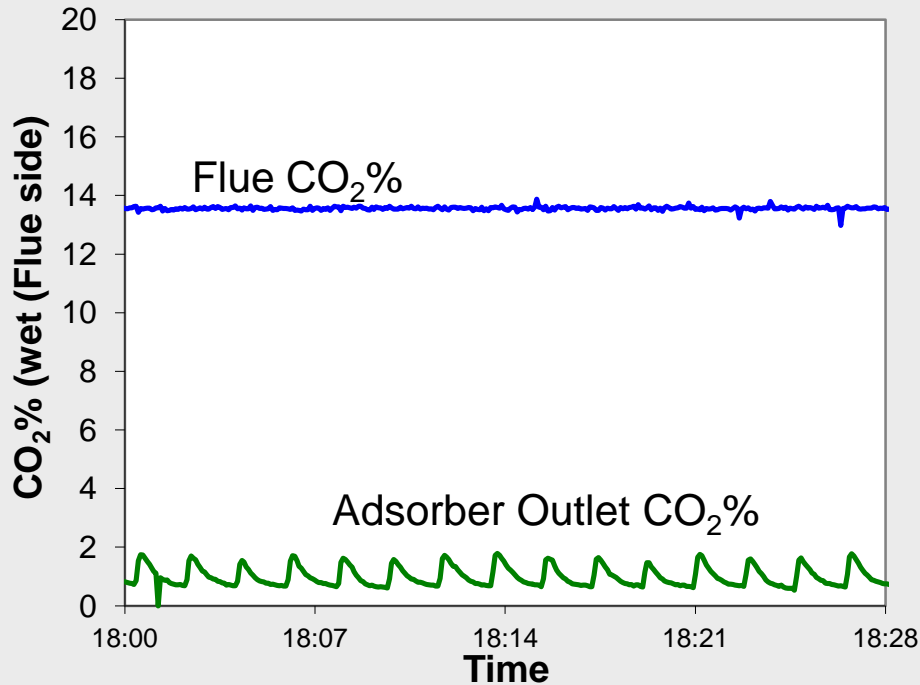
Regeneration side



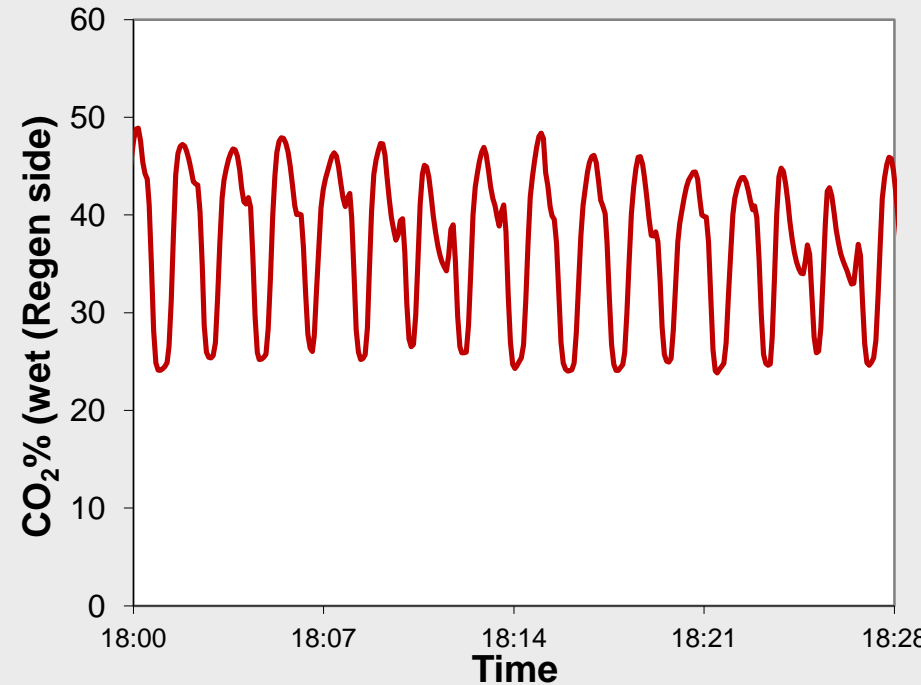
- Results stable over 5 days of testing
- Loading 0.88 wt% and 89.3% capture

# Additional Testing at TDA

Flue Gas side



Regeneration side



- **Cycle time adjusted**
- **Loading 0.90 wt% and 90% capture achieved**

# Field Testing at WRI

- Western Research Institute (WRI) is located in Laramie, WY.
- Combustion Test Facility is a pilot-scale coal combustion system that simulates a pulverized coal-fired utility boiler. It is a balanced-draft system that was set up to simulate a tangential-fired power plant.



- Combustion Test Facility has a nominal coal firing capacity of 250,000 Btu/hour.
- Testing was done with Powder River Basin Decker coal.

# Test Conditions

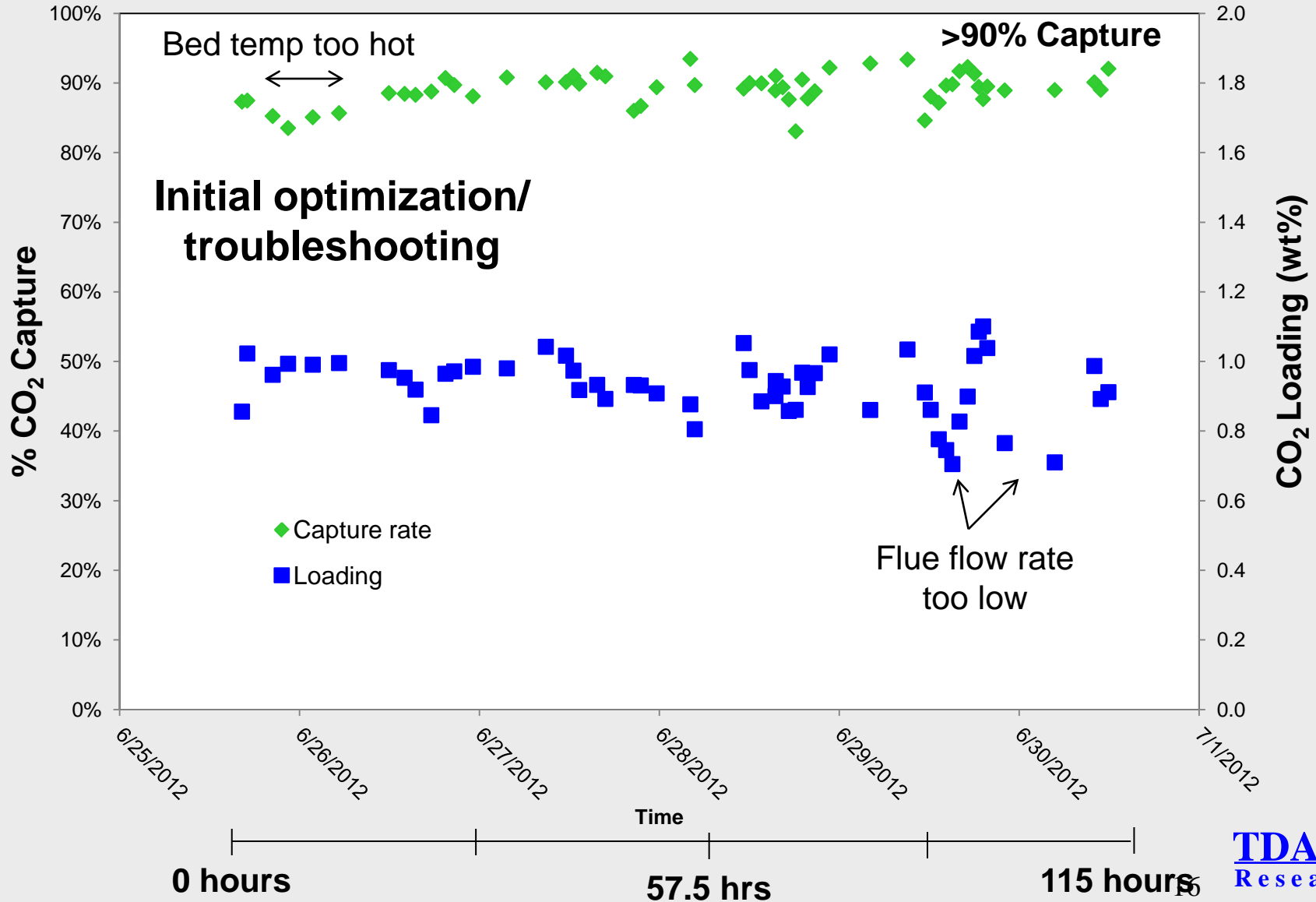
- Flue gas, ~17 psi
  - 11-14% CO<sub>2</sub>
  - ~6% H<sub>2</sub>O
  - 5-145 ppm NO
  - 2-11 ppm NO<sub>2</sub>
  - 0-15 ppm SO<sub>2</sub>

- SO<sub>2</sub> was reduced upstream of TDA apparatus



- Extended cycling run for 5 days
- Cycling conditions optimized over test for various feed compositions

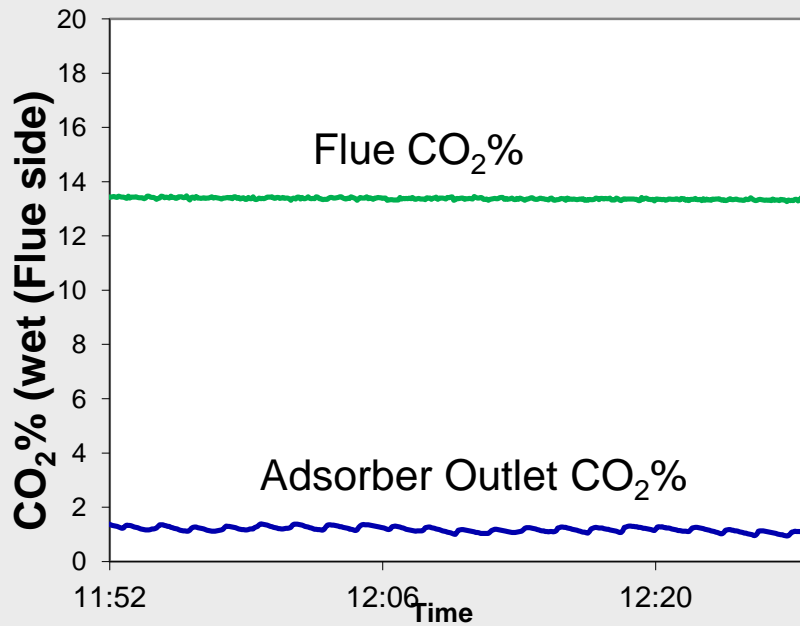
# Extended Cycling at WRI



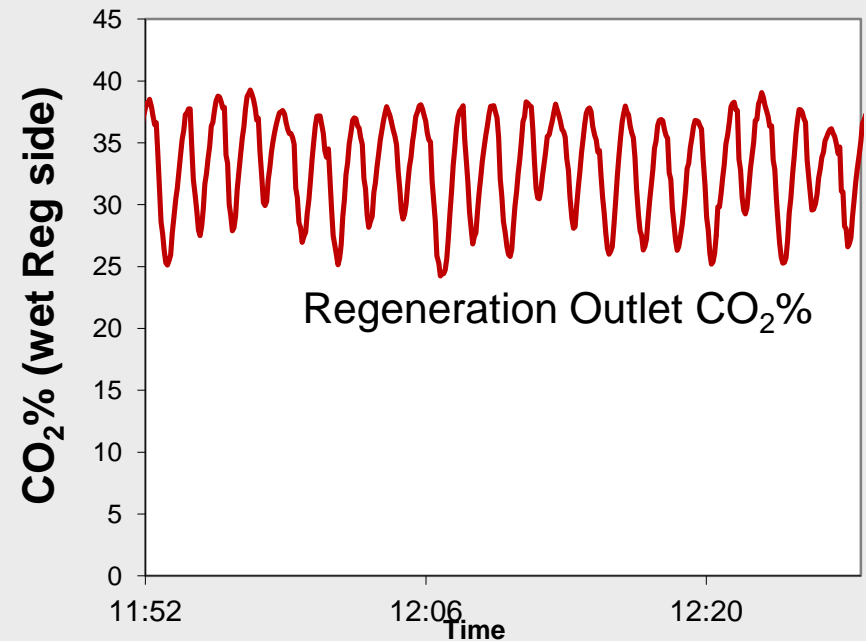


# Field Testing at WRI (Day 5)

Flue Gas side



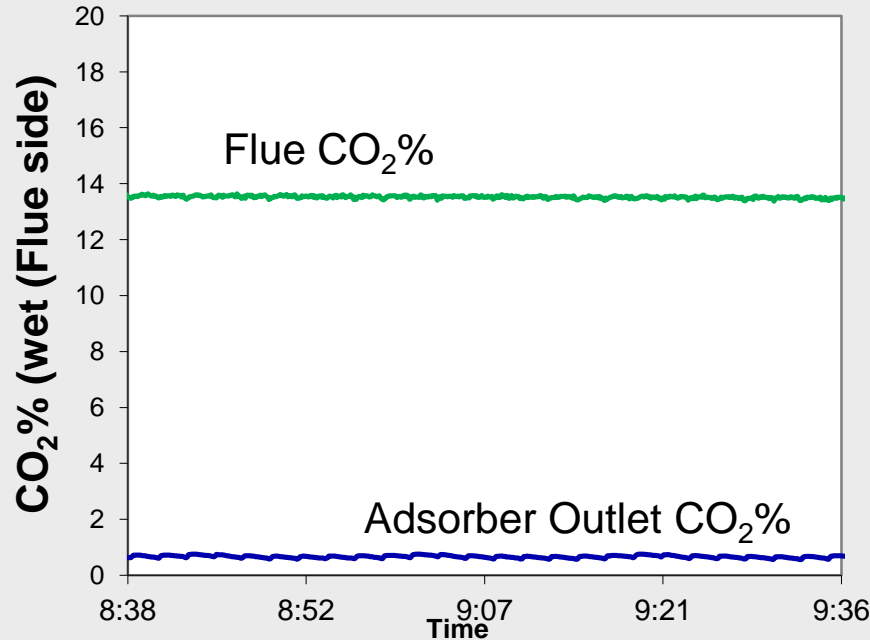
Regeneration side



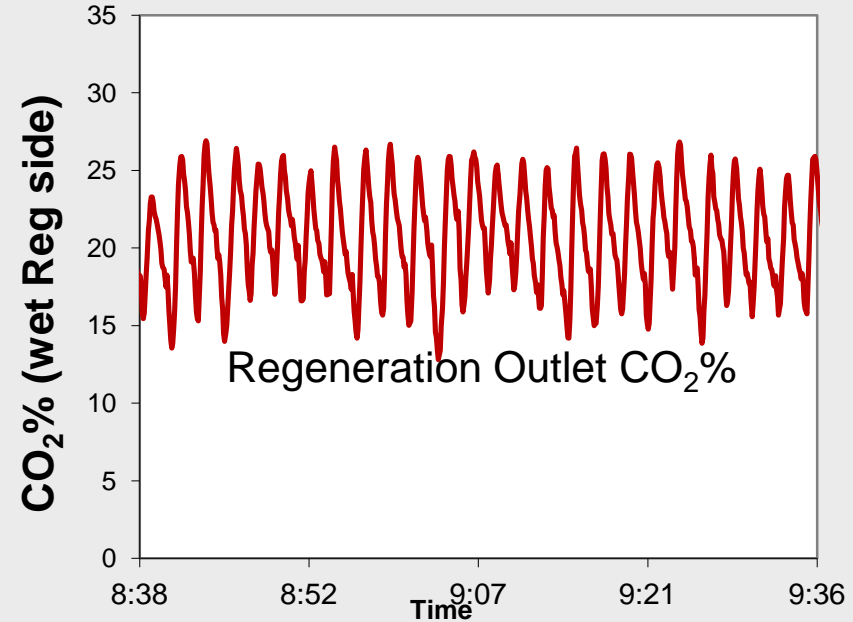
- Day 5 data of extended cycling test on real coal derived flue gas
- 0.86 wt% loading, 89% capture

# Results of Field Test (Day 5)

Flue Gas side

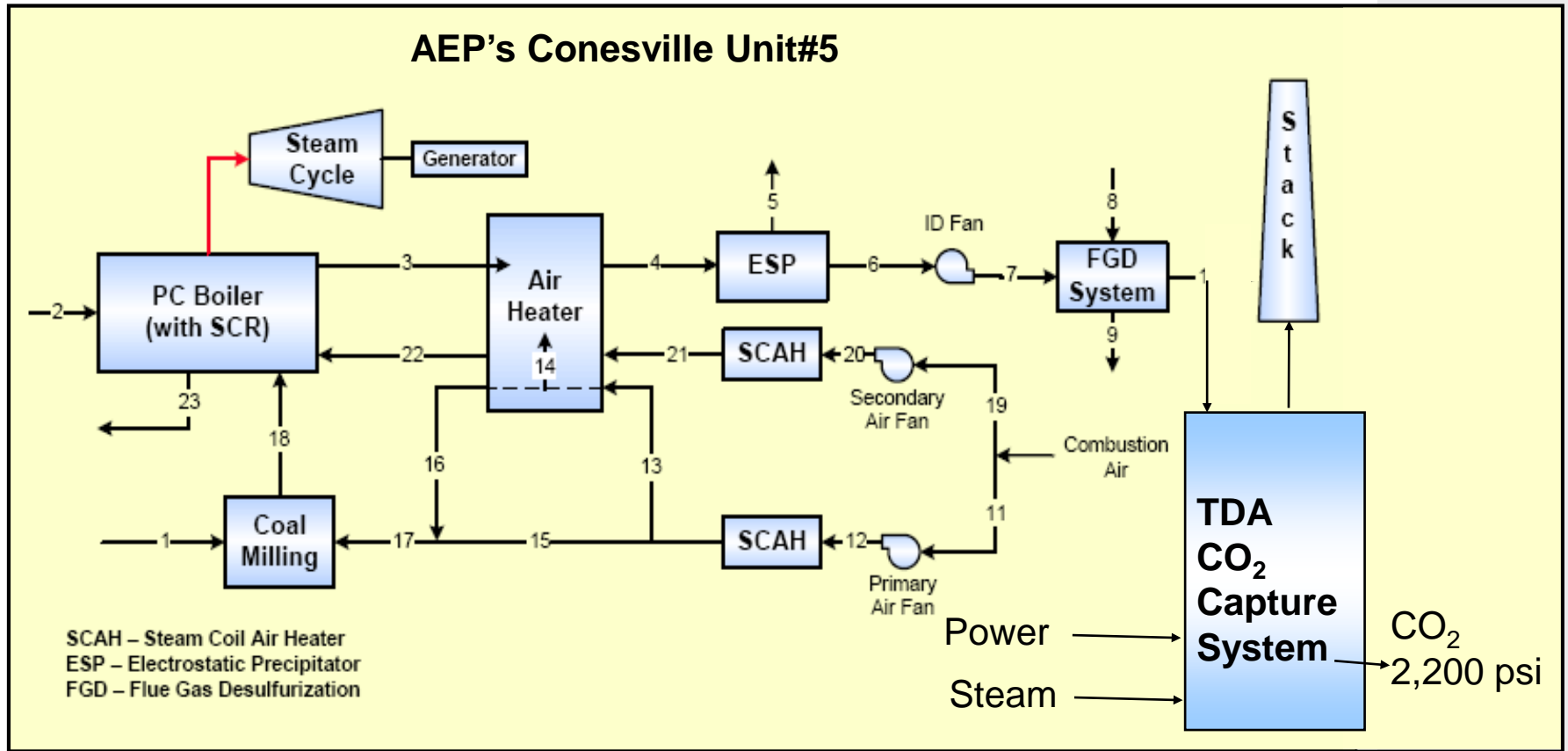


Regeneration side



- Improved capture with additional steam
- 1.03 wt% loading, 93% capture

# System Analysis



## Integration of TDA's system as a retrofit to Conesville Unit #5

433.7 MW plant, 10,393 tons/day CO<sub>2</sub> generated (DoE/NETL-401/110907)

# System Economics

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- **TDA and B&W System Analysis & Economics**
  - Babcock & Wilcox Power Generation Group is performing work under subcontract
  - Simulation built in Aspen Plus
  - Several reactor designs considered
  - System and economic analysis underway
- **NETL Pathways Study**
  - TDA technology was included in this pathways study done by DoE to compared different post combustion CO<sub>2</sub> capture methods

# Summary

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- TDA is developing both a sorbent and process that uses the sorbent for post combustion CO<sub>2</sub> capture coal fired power plants.
- Bench-scale apparatus as been demonstrated at TDA with improved performance with addition of purge bed.
- Sorbent has stable cycling performance in bench-scale.
- Field testing at WRI has been completed:
  - Sorbent tested for over 100 hours with real coal derived flue gas
  - 90% capture demonstrated

# Future Work

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- Update system analysis with experimental data and determine process economics
- Additional bench-scale testing at TDA as needed to support modeling conditions
  - Evaluation of other optimums besides at 90% capture

# About TDA

- **Began operations in 1987**
- **Today**
  - 85 employees, over 60% with advanced degrees
- **Facilities**
  - Combined 50,000 ft<sup>2</sup> in Wheat Ridge and Golden, CO
- **Areas**
  - New materials development
  - Processes for Energy/chemicals
- **Business Model**
  - Perform R&D, primarily under government contract
  - Secure intellectual property
  - Commercializes technology by licensing, joint ventures, internal business units



# Acknowledgments

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- **DOE project funding**
- **Collaborators**
  - B&W
  - LSU
  - WRI