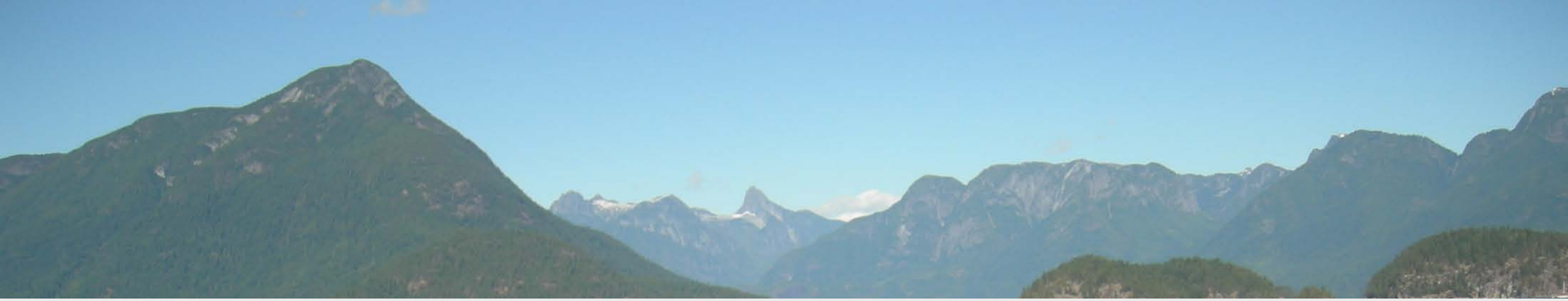

Evaluation of Solid Sorbents as a Retrofit Technology for CO_2 Capture from Coal-Fired Power Plants

Holly Krutka, Sharon Sjostrom, Tom Campbell, Travis Starns
ADA Environmental Solutions

DE-NT0005649

NETL CO_2 Capture Technology Meeting • September 13, 2010

Presentation Outline

- Project Description
- Sorbents
  - Laboratory analysis
  - 1 kW pilot analysis
- Equipment
- Conclusions

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Project Description

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Phase I: Dual Focus Viability Assessment

Sorbents

- Lab Screening
- Lab-Scale Field Screening
- 1 kW Pilot Testing

Equipment

- Survey & Assessment
- Costs & Impacts
- Design
  - 500 MW Concept

<u>Objective</u>: *Assess the viability and accelerate development of solid-sorbents for CO_2 capture on the existing fleet of coal-fired power plants*

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Phase I Project Team

DOE NETL Team Members

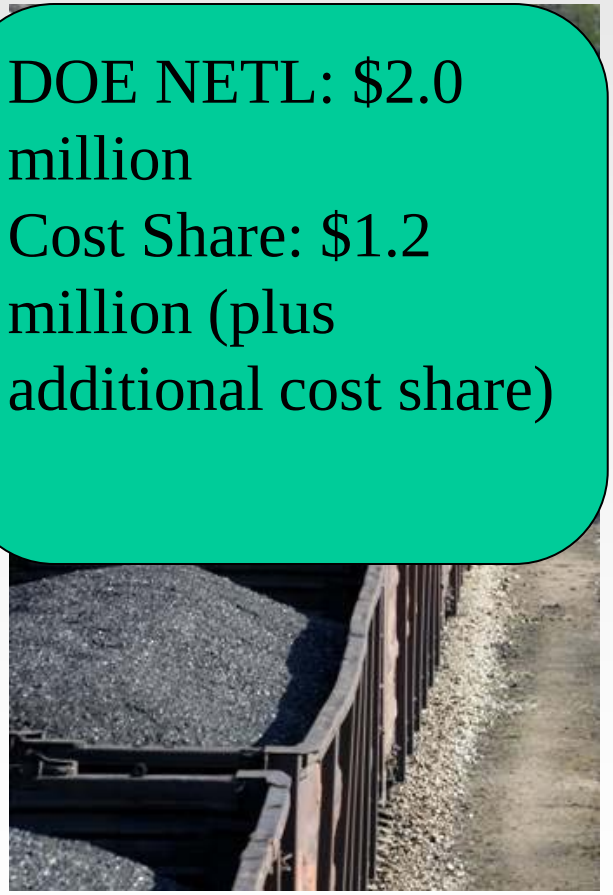
- ADA
- NETL
- EPRI
- AEP
- Ameren
- North American Power
- Luminant
- Southern Company
- Xcel Energy

Additional EPRI Member Participation and Support

- TVA
- FirstEnergy
- DTE

Key Contractors:
Stantec, Pressure Chemical

DOE NETL: $2.0 million
Cost Share: $1.2 million (plus additional cost share)



DOE Cooperative Agreement: DE-NT0005649

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Technical Approach

Phase I: Viability → **Phase II: Pilot Testing (1 to 5 MW)** → **Phase III: Demonstration (> 30 MW)** → **Commercial Implementation**

Phase I: Assess Viability

- **Technical**
  - $\geq$ 90% CO_2 capture
  - Produce high purity CO_2
  - Scalable Sorbent
  - Scalable Equipment
- **Economic**
  - $\leq$ 35% increase in COE
    - Capital Cost Drivers
      - Size of Equipment
      - Materials of Construction
      - Process Complexity
    - Operating Cost Drivers
      - Energy to release CO_2
      - Energy to compress CO_2
      - Sorbent Replacement

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Sorbent Evaluation

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Contribution of Lab-Scale Results

Goals	Progress to Date
Compare many different materials under the same simulated flue gas conditions	Over 100 materials developed and collected from 22 different sources to date (78 since 10/08)
Use laboratory screening to select materials for lab-scale field testing	Four lab-scale field tests completed since 10/08 (1 Luminant, 2 DOE, 1 EPRI/TVA)
Use all lab-scale results to select materials for 1 kW evaluation	Three materials produced in 600 lb quantities based on lab-results (separate EPRI and First Energy funding)
Work iteratively with sorbent developers to improve sorbent properties	Currently evaluating several 2nd and 3rd generation materials with significantly improved properties

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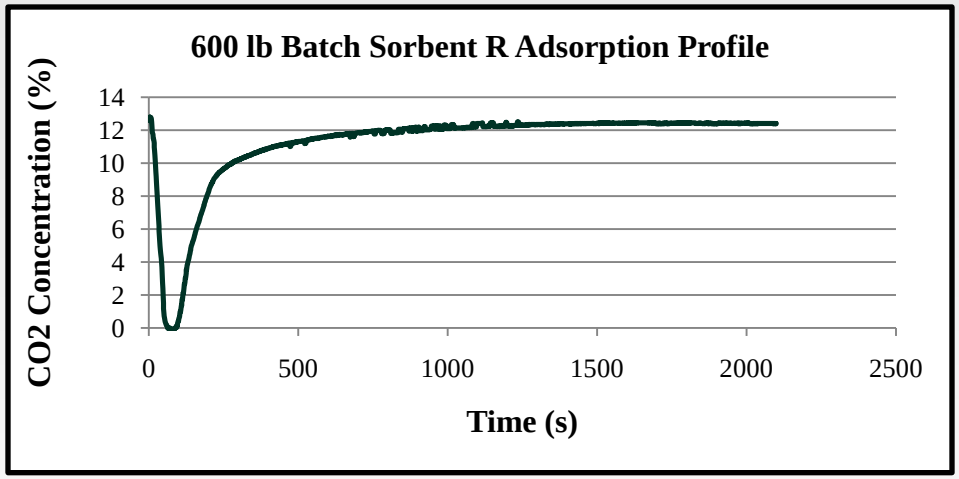
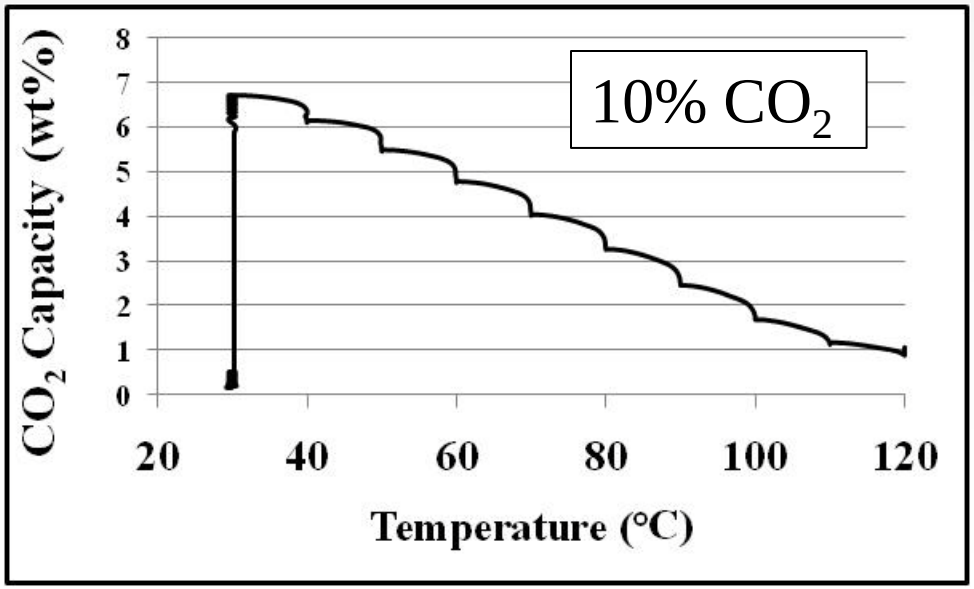
Laboratory Tests

- Fixed Bed Breakthrough Curves
  - CO_2 Capacity
  - Long term cyclic stability
  - Poisoning by SO_2, etc.
- Thermogravimetric Analysis (TGA)
  - Working Capacity
  - Temperature stability
  - Uptake of other flue gas constituents





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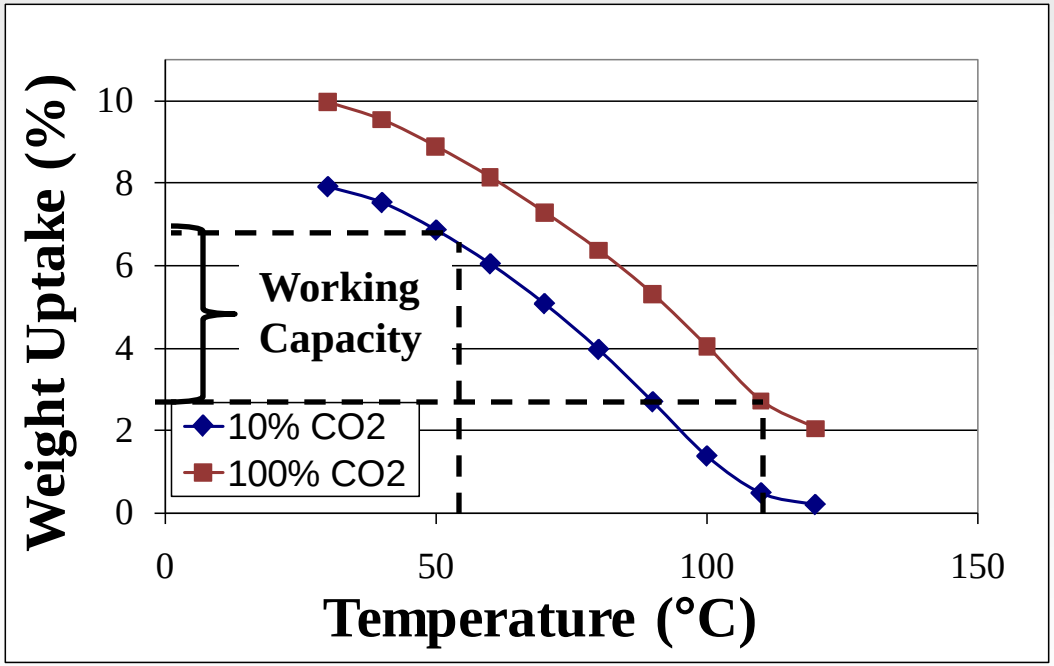
Key Sorbent Performance Characteristics

- Operating Temperature Range
- Stable Under Humid Conditions
- CO_2 Working Capacity
- Kinetics
- Long-Term Stability
- Affordable at Commercial-Scale



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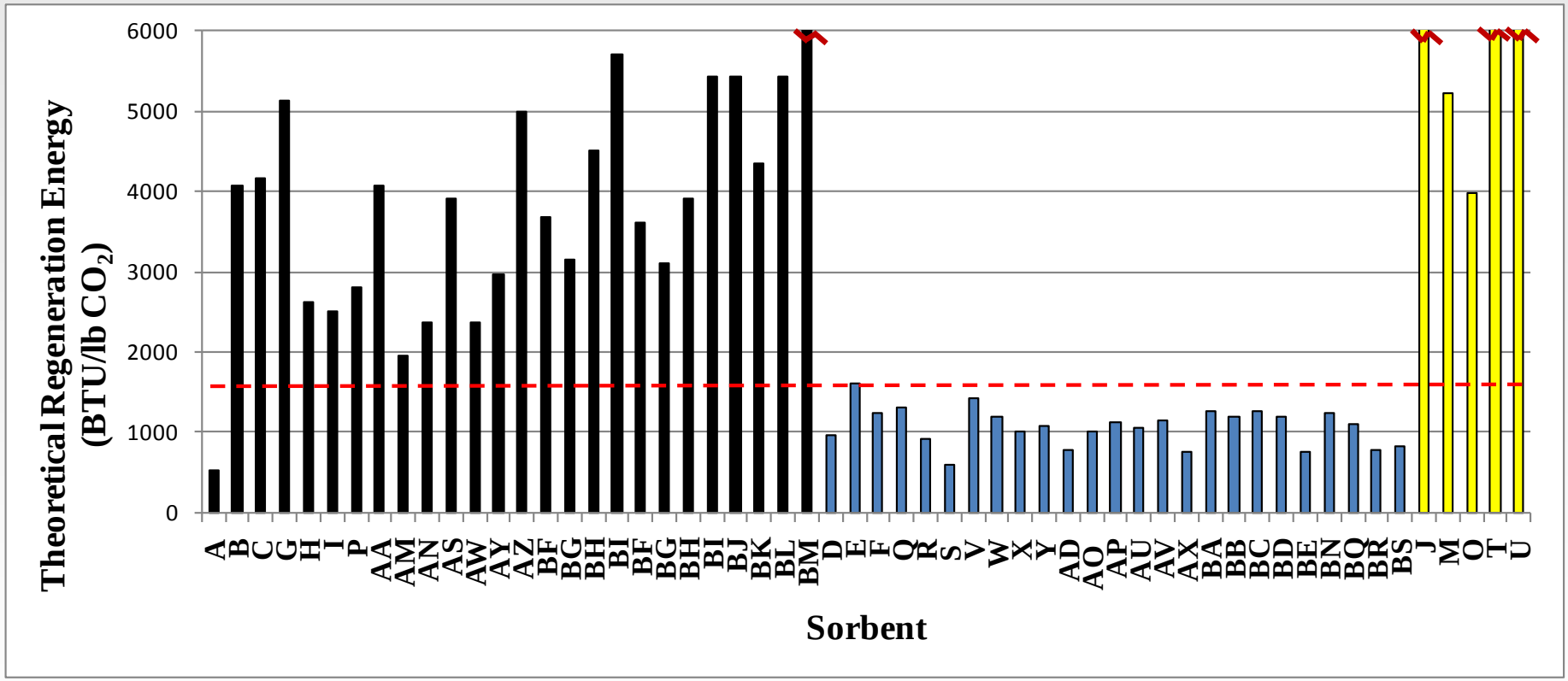
Key Findings: Regeneration Energy



Ramezan M., Skone T.J., Nsakala N., Liljedahl G.N., "Carbon Dioxide Capture from Existing Coal-Fired Power Plants", Final Report DOE/NETL-401/110907, December, 2007.

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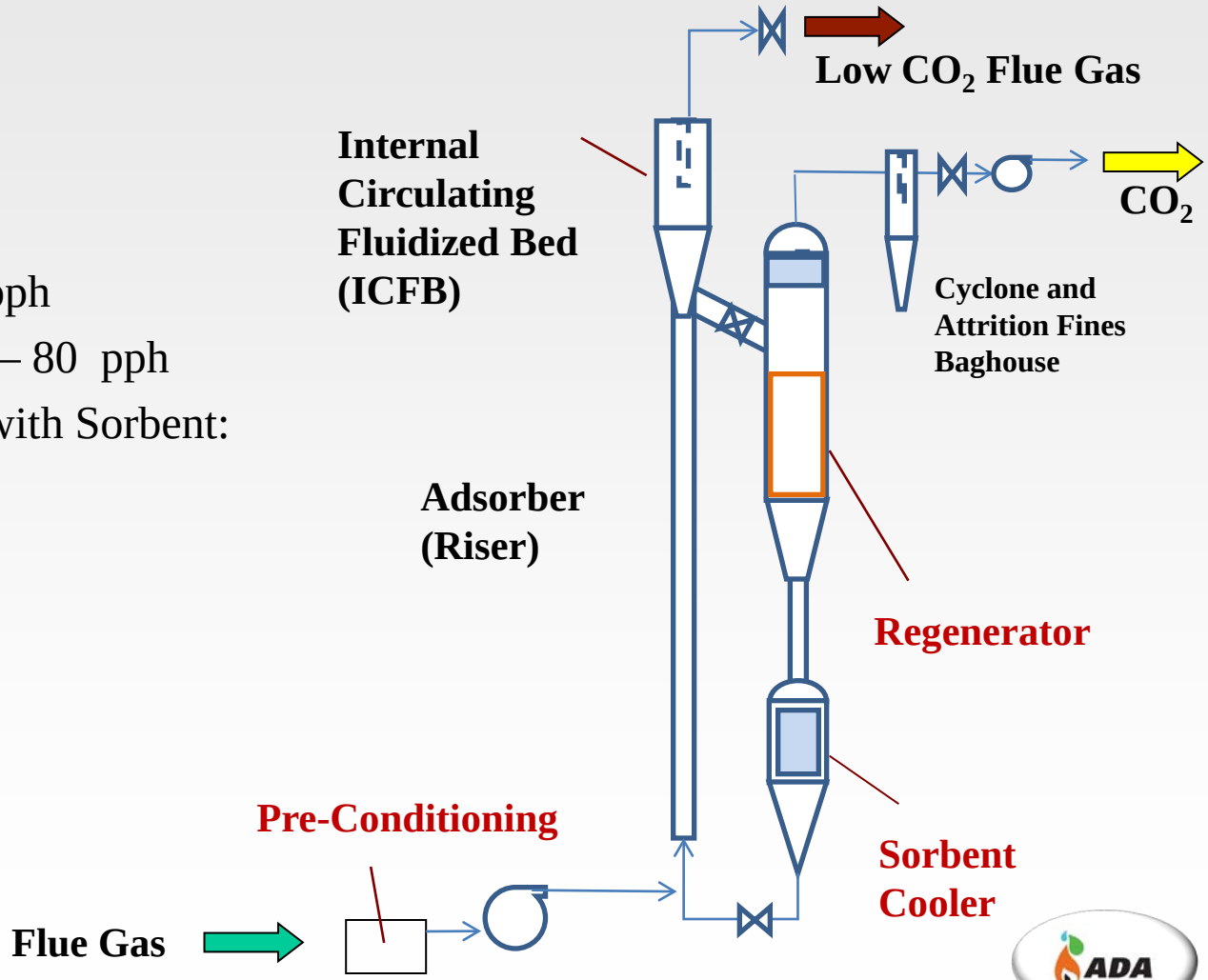
1kW Pilot System

- Raw Flue Gas Flow Rate:
  ~ 5 acfm/22 pph
- Inlet CO_2 Flow Rate: 2.6 pph
- Sorbent Flow Rate: ~ 40 – 80 pph
- Flue Gas Exposure Time with Sorbent:
  ~ 2.2 sec

Concept provided by Southern Company



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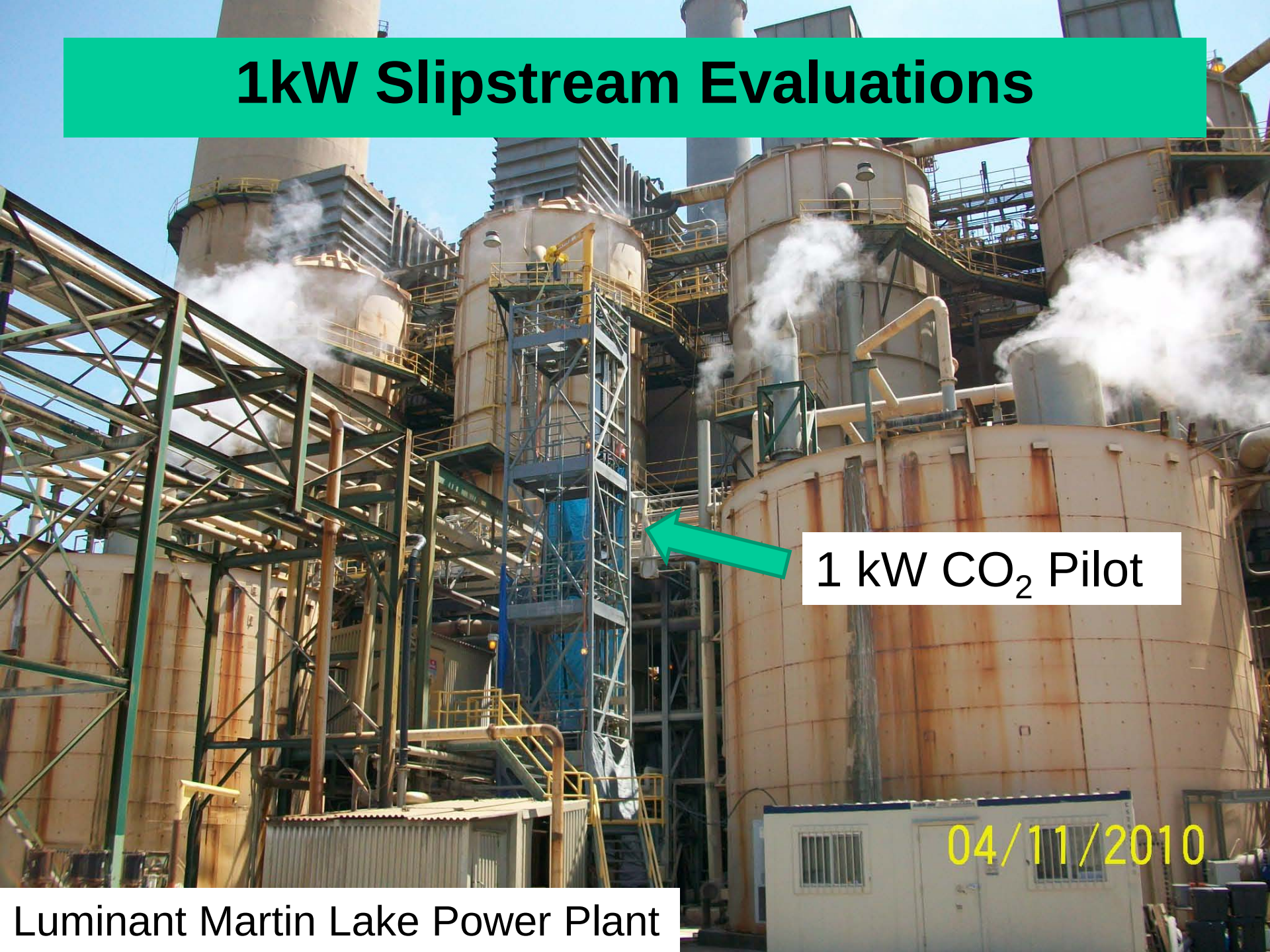
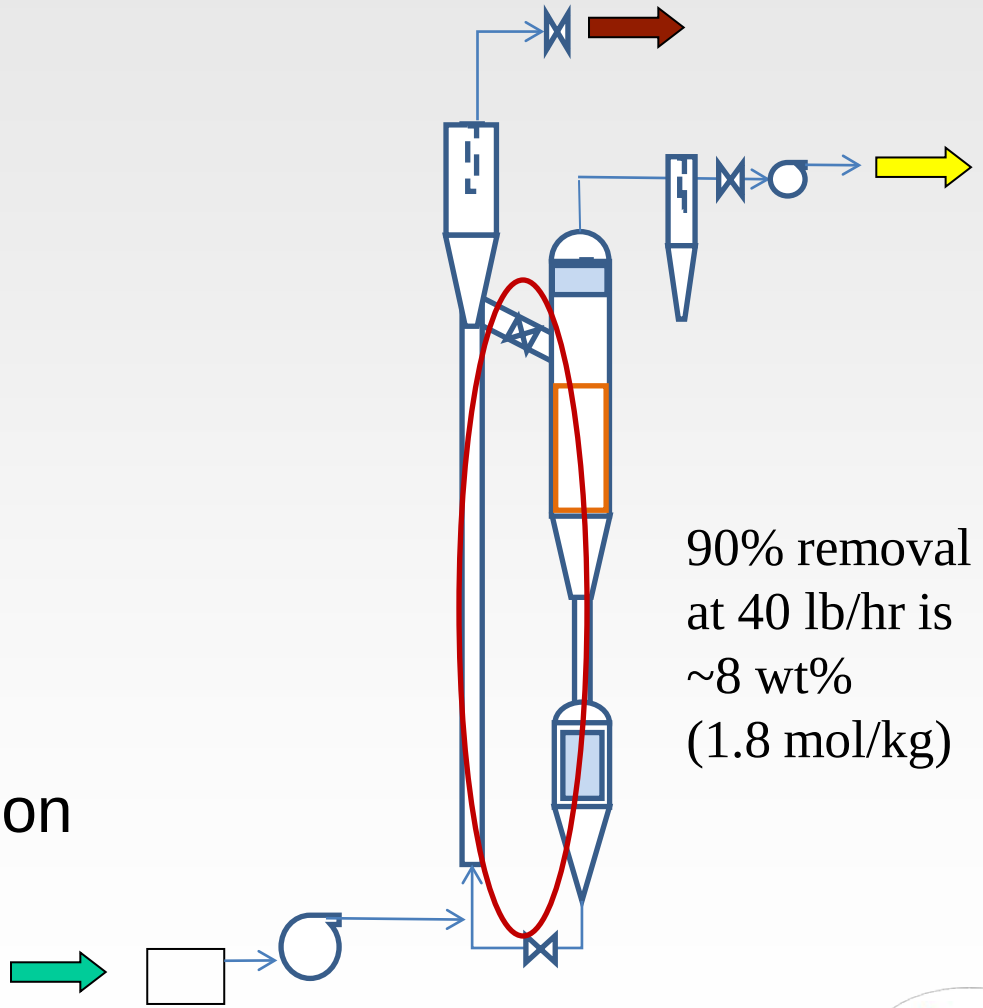
1kW Slipstream Evaluations



Luminant Martin Lake Power Plant

System Operation

- Continuous
  - Adsorption and regeneration simultaneously
- Batch
  - Adsorption and regeneration are separate
  - Increase regeneration time



90% removal at 40 lb/hr is ~8 wt% (1.8 mol/kg)

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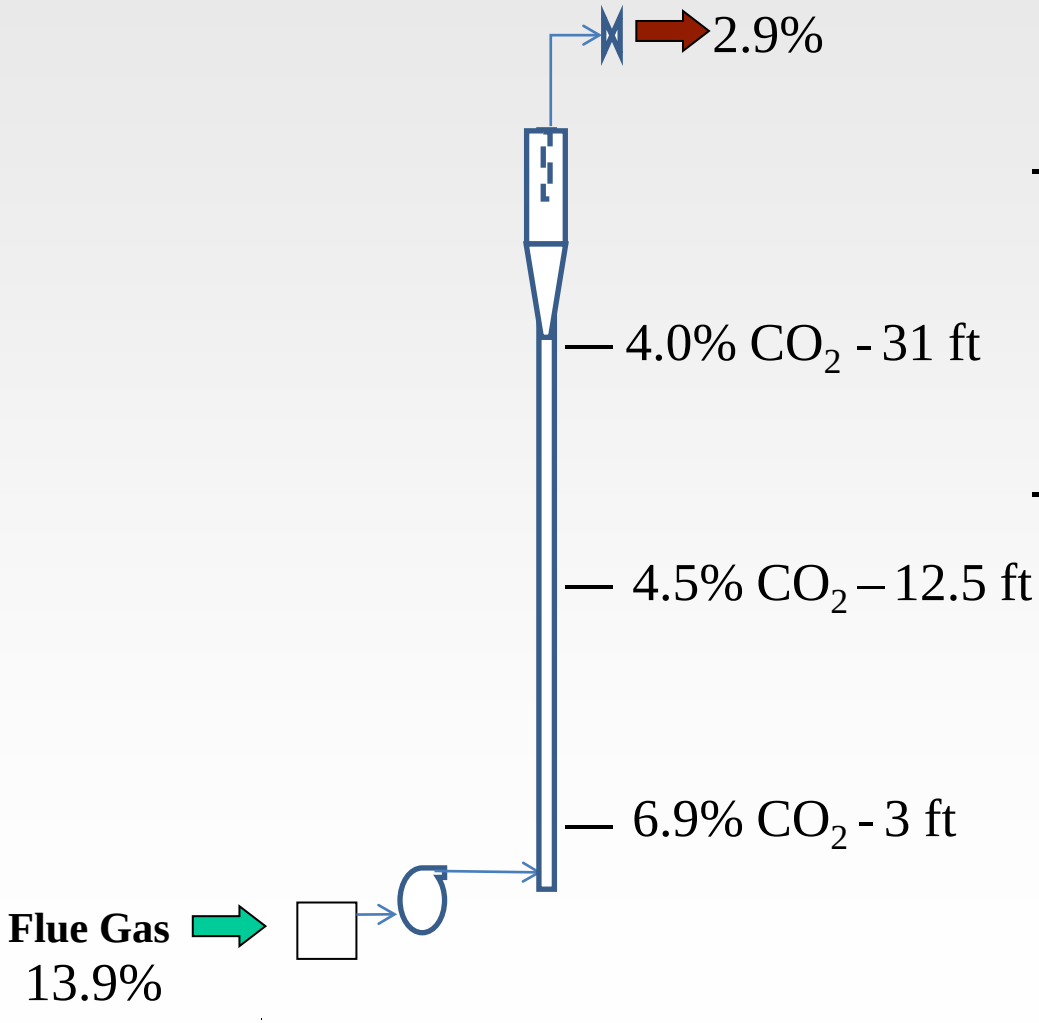
CO_2 Profile in Riser (example)



Rapid Adsorption

- Pros:
  - Strong CO_2 affiliation
  - High selectivity
  - Minimizes contact time
- Cons:
  - Significant temperature bulge that is difficult to control

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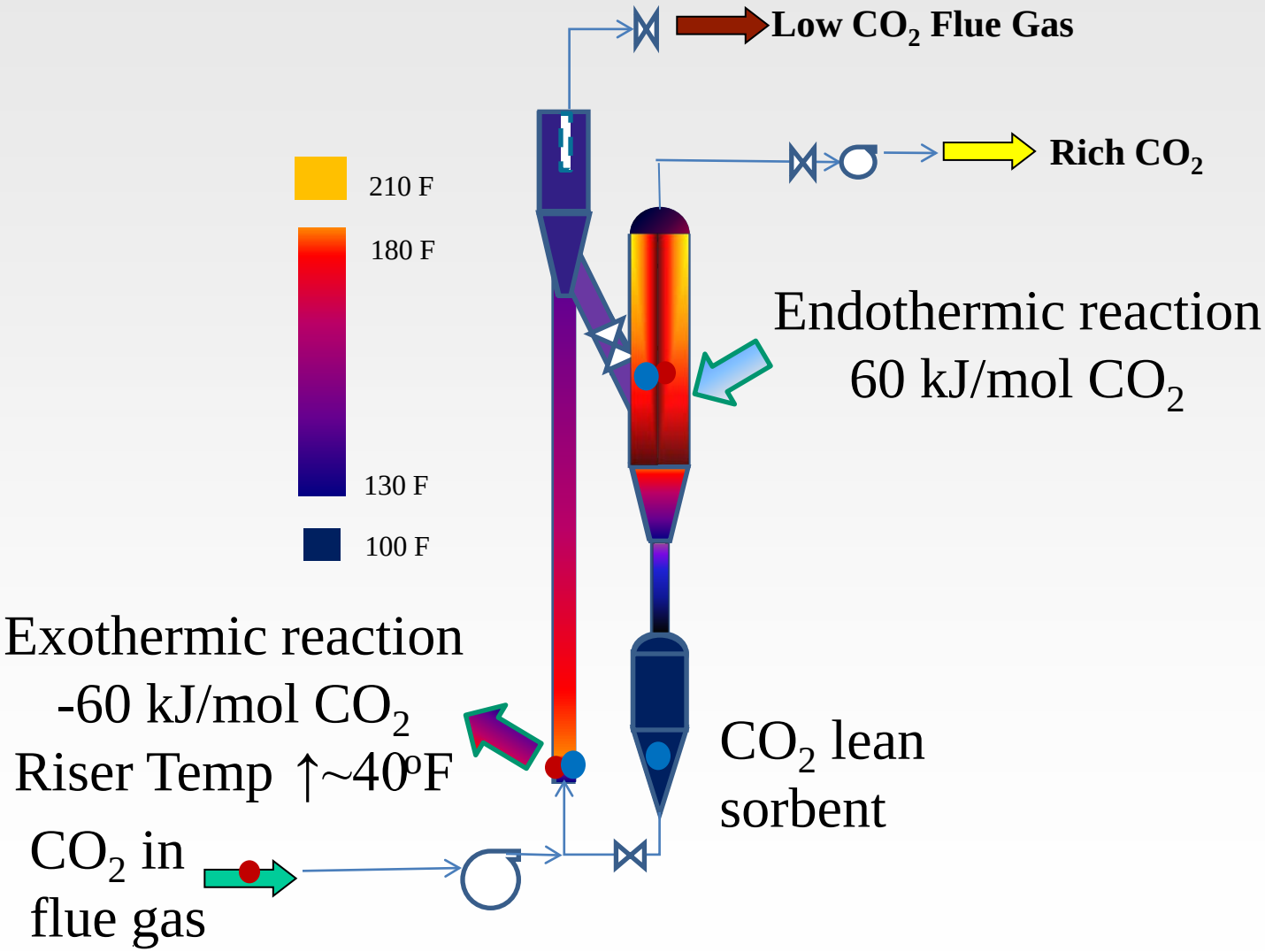
1 kW Pilot with Sorbent R



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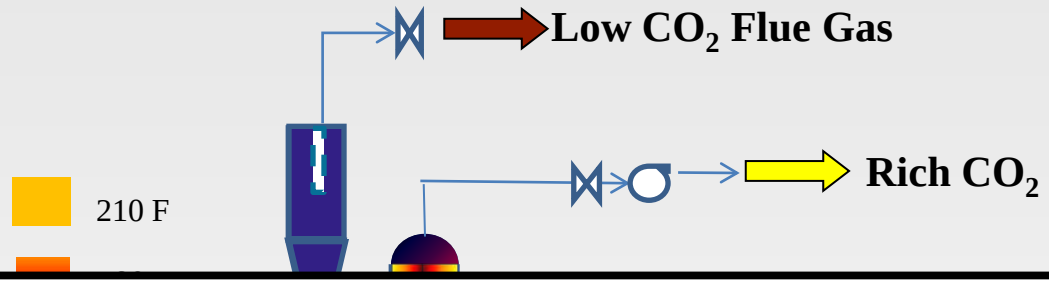
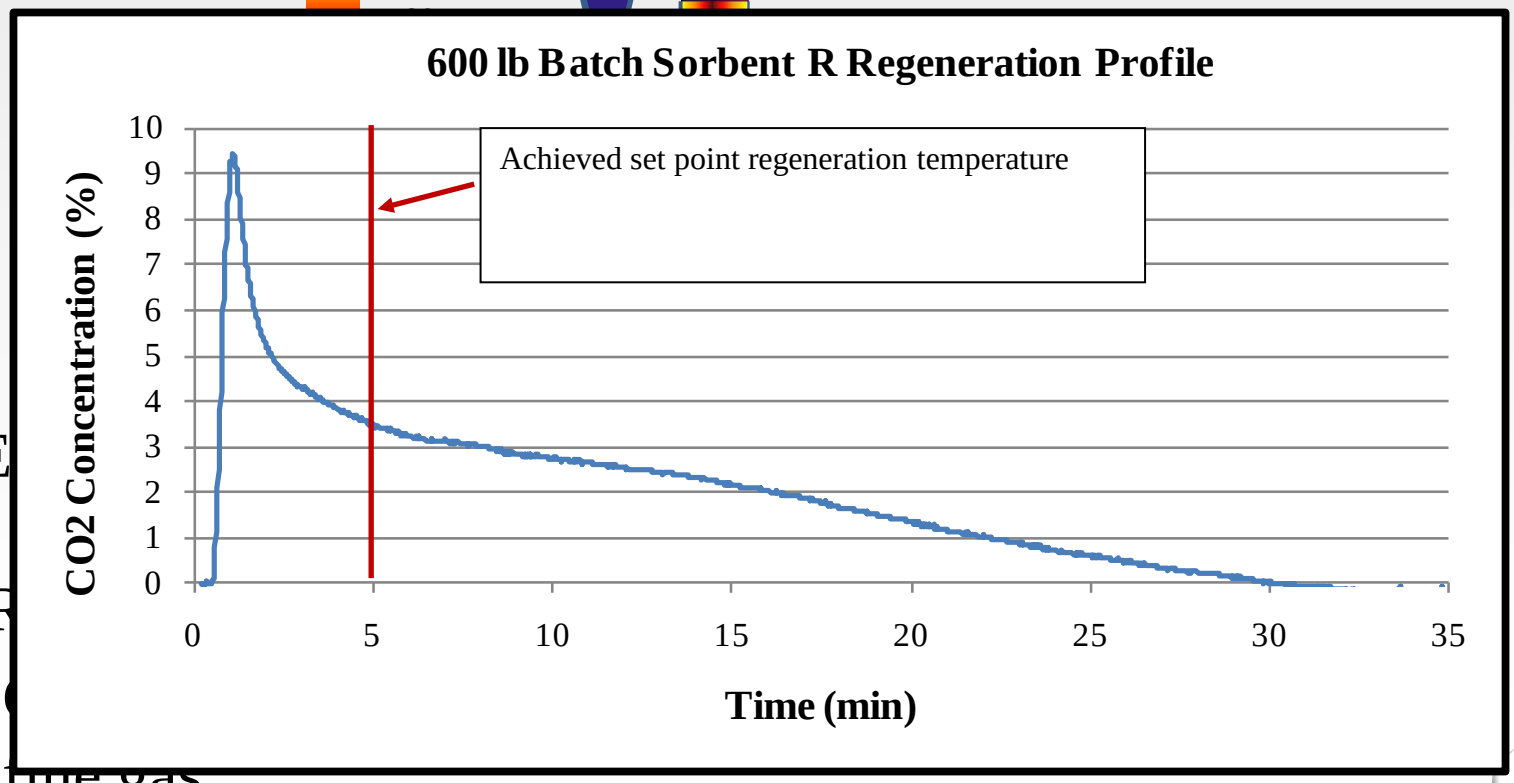
1 kW Pilot with Sorbent R





E

R

flue gas

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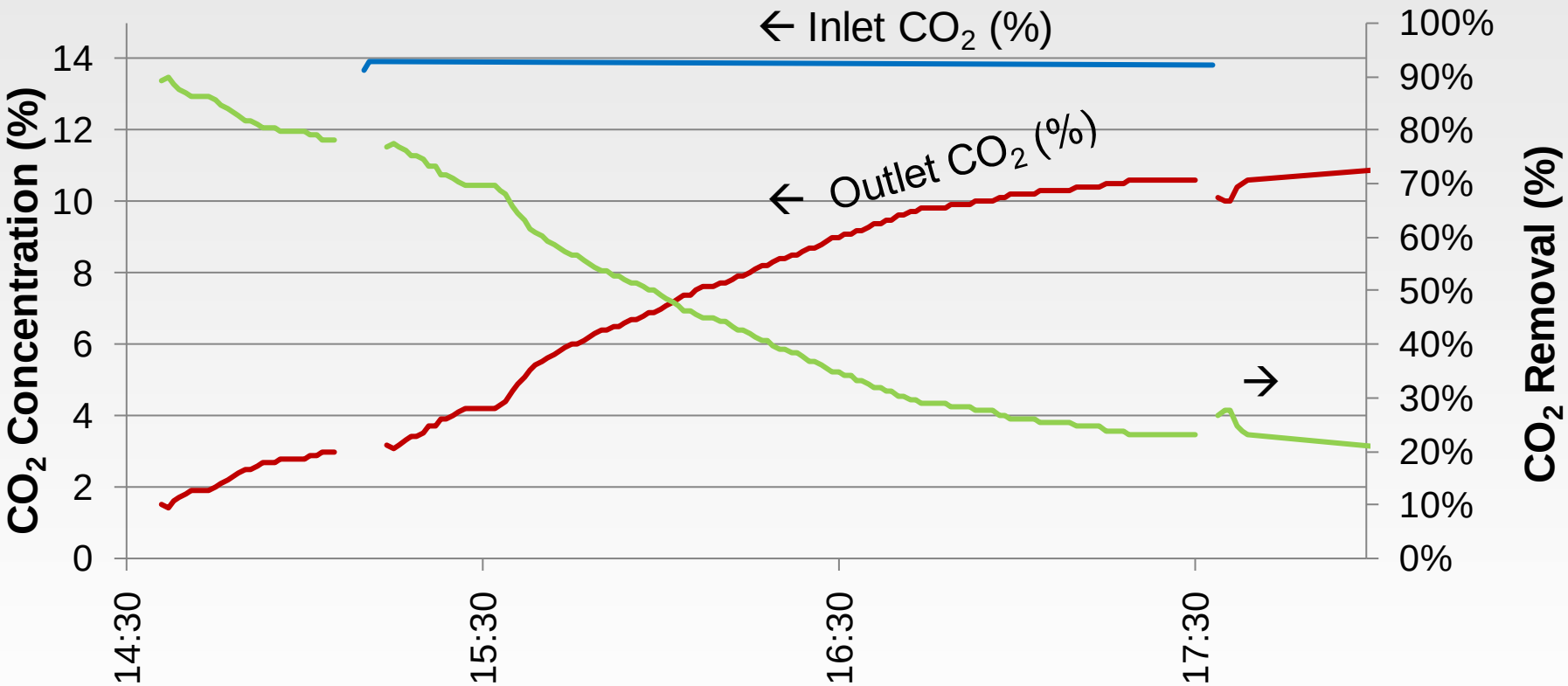
Continuous Testing



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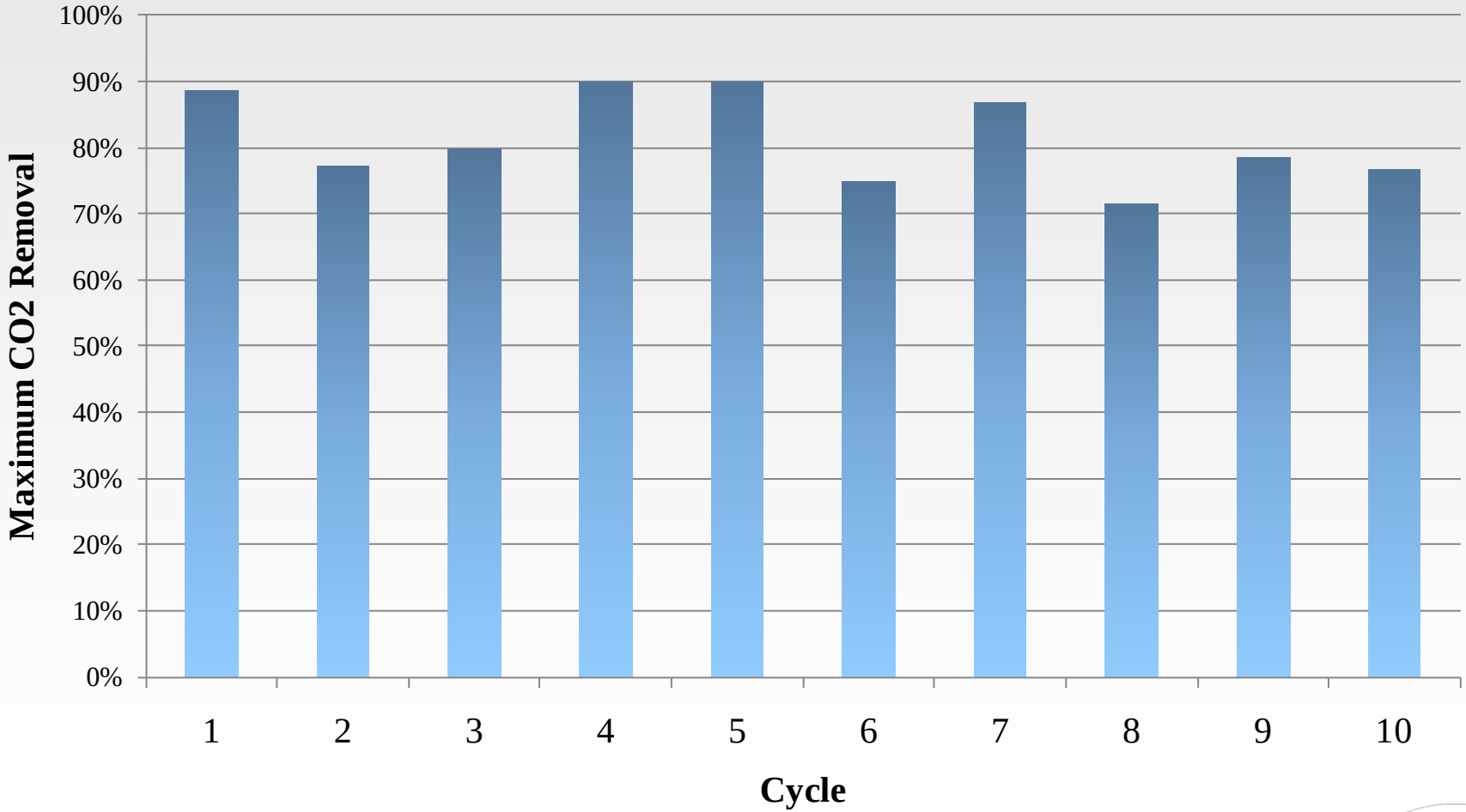
Batch Test Summary



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1 kW Summary of Results

- ✓ > 90% capture achieved
- ✓ Fast adsorption reaction
  - ➢ Significant removal at < 1 sec. residence time
- ✓ Pressure drop: 2.5 – 3 in H2O (includes ICFB) at 40 lb/hr circulation
- ☒ Slow regeneration with test sorbent (R)
  - ➢ Batch operation required to characterize performance in this pilot

Successful sorbents must regenerate quickly and/or in the presence of increased CO_2 concentrations.

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Commercial Scale Equipment Evaluation

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Approach

Phase I: Viability Assessment

High-Level Capital and Operating Cost: Estimates are being calculated using existing commercial technologies with features similar to those required for CO_2 capture process

Technology survey → Scoring → Final Technology Selection

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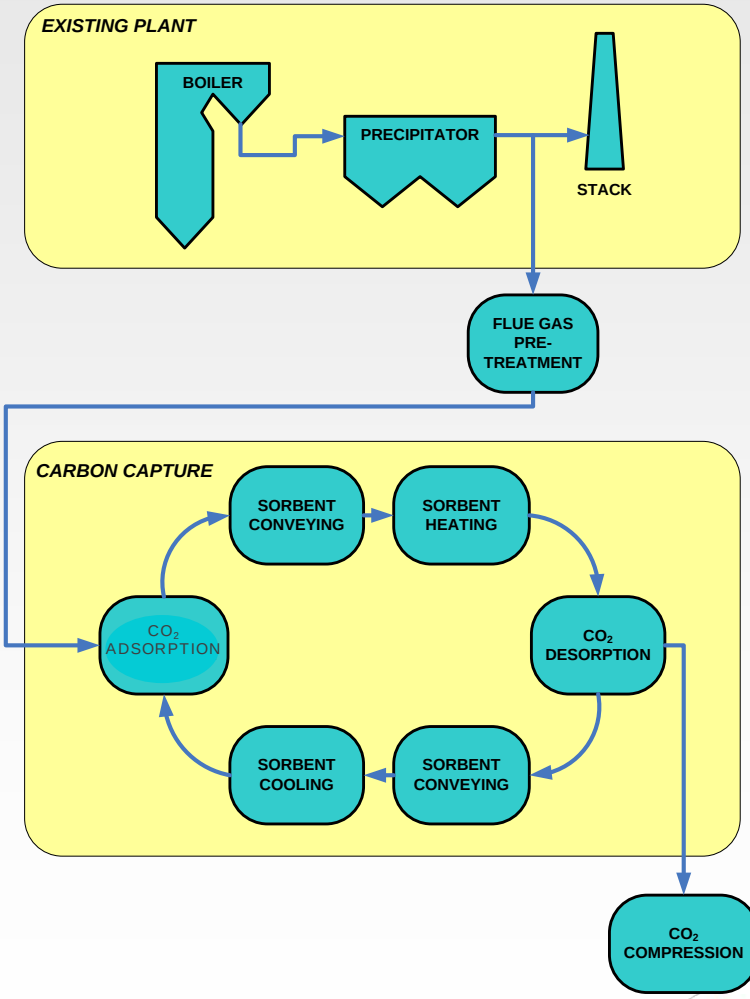
Post Combustion CO_2 Capture

- Adsorption
- Conveying
- Heating/Cooling
- Desorption (i.e. Regeneration)

Multiple process steps may be performed simultaneously in the same piece of equipment.

Example: Heating and regeneration



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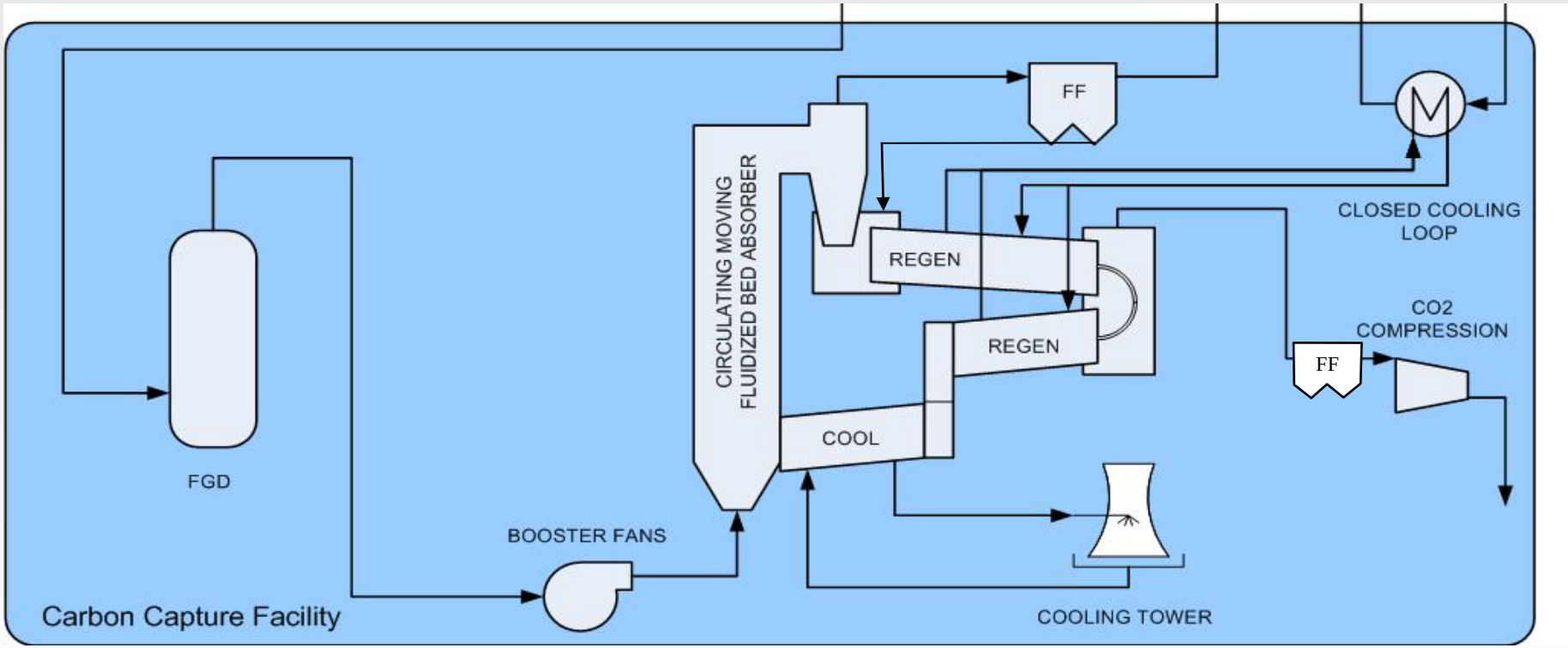
CO_2 Capture Process Concept



Use this technology to develop preliminary estimates for costs.

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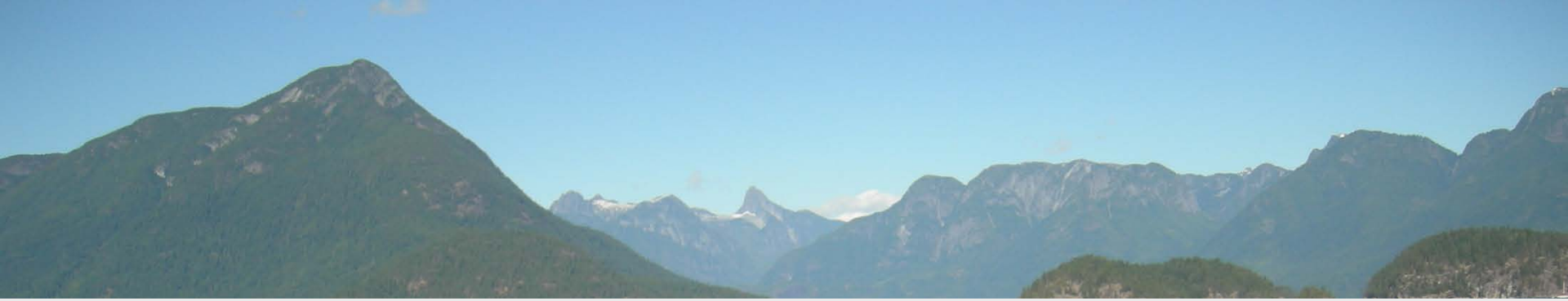

Questions?

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