INSTITUTE FOR ENERGY STUDIES
THE UNIVERSITY OF NORTH DAKOTA

Evaluation of Carbon Dioxide Capture From Existing Coal Fired Plants by Hybrid Sorption Using Solid Sorbents

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Envergex
Sparking Innovations

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Presentation Overview

- Project Overview
- Technology Fundamentals
- Project Scope
- Current Status
- Plans for Future Testing

Project Team

- US Department of Energy - NETL
- UND Institute for Energy Studies
- Envergex LLC
- Lignite Energy Council/NDIC
- ALLETE Group
    - Minnesota Power
    - BNI Coal
- SaskPower
- Barr Engineering
- Solex Thermal

Project Objectives

- Develop a process using solid sorbents that will efficiently capture CO_2 from flue gas streams and regenerate into a pure CO_2 stream, with a lower operating cost than current methods.

- Goal: 90 percent CO_2 removal at no more than 35 percent increase in the cost of electricity.

- Combine existing technologies to create a new sorbent which will have high CO_2 loading capacity and a process with low reaction energies.

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Budget – Funding Sources

Performance period: 10/1/11 to 09/30/14

Total Funds = $3.69 Million

Background on the Proposed Technology and Scientific/Technical Merit

Technology Background

- The hybrid sorption CACHYS^{TM} process uses an additive-enhanced regenerable alkali carbonate sorbent for CO_2 capture.

Reactions

$$M_xN_y\text{(carbonate-based)} + a.CO_2(g) \longrightarrow \text{Product}$$

$$\text{Product} + \text{Steam} \xrightarrow{\Delta} M_xN_y + a.CO_2(g)$$

- Sorbents prepared from bulk commodity materials – low cost target.
- Reacts with CO_2 to form adduct. Reversible with the addition of heat.
- Additive – increases adsorption kinetics and reduces sorption energy.
- Initial concept testing conducted by Envergex and UND under DOE STTR program.

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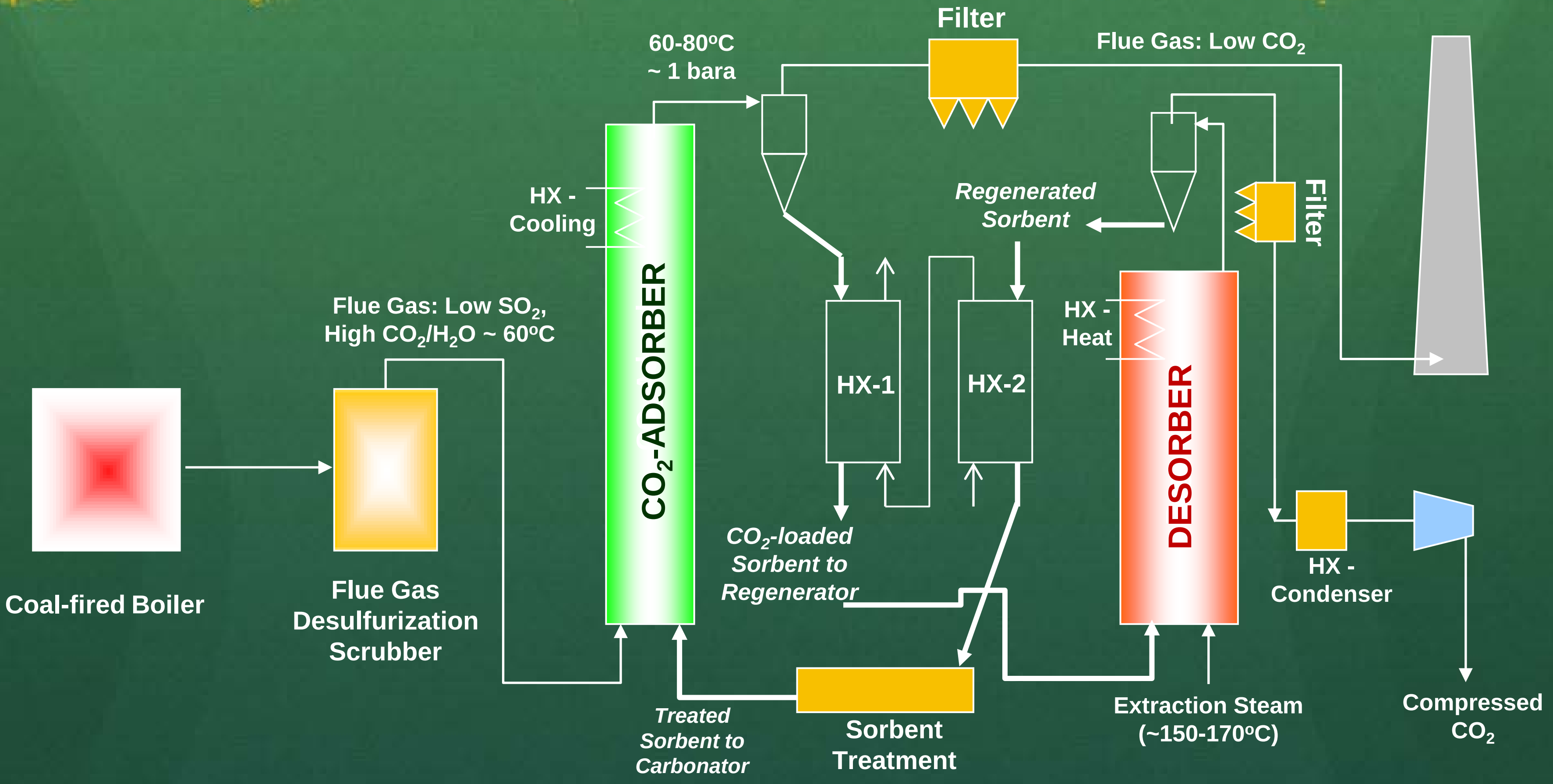
CACHYS™ Hybrid Sorption Process



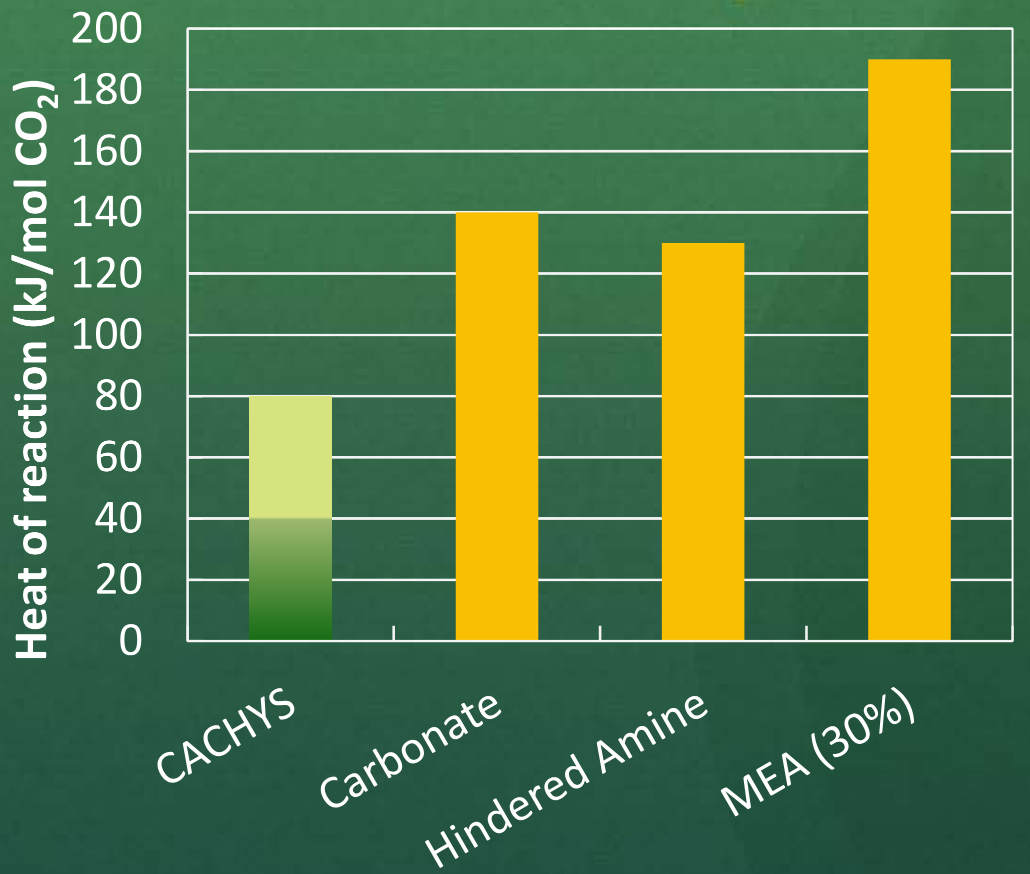
CACHYS™ Process Benefits

Benefits

- ✓ Low reaction heat ~ 40-80 kJ/mol CO_2
- ✓ High sorbent capacity
- ✓ Increased sorption kinetics
- ✓ Use of low cost, abundantly available materials

Challenges

- ✓ Confirmation of energetics
- ✓ Confirmation of sorbent capacity
- ✓ Sorbent integrity
- ✓ Sorbent handling



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Project Scope

Technical Approach and Project Scope

- Scope of work includes eight main tasks:
  - Task 1: Project Management and Planning
  - Task 2: Initial Technology and Economic Feasibility Study
  - Task 3: Determination of Hybrid Sorbent Performance Metrics
  - Task 4: Bench-Scale Process Design
  - Task 5: Bench-Scale Process Procurement and Construction
  - Task 6: Initial Operation of the Bench-Scale Unit
  - Task 7: Bench-Scale Process Testing
  - Task 8: Final Process Assessment

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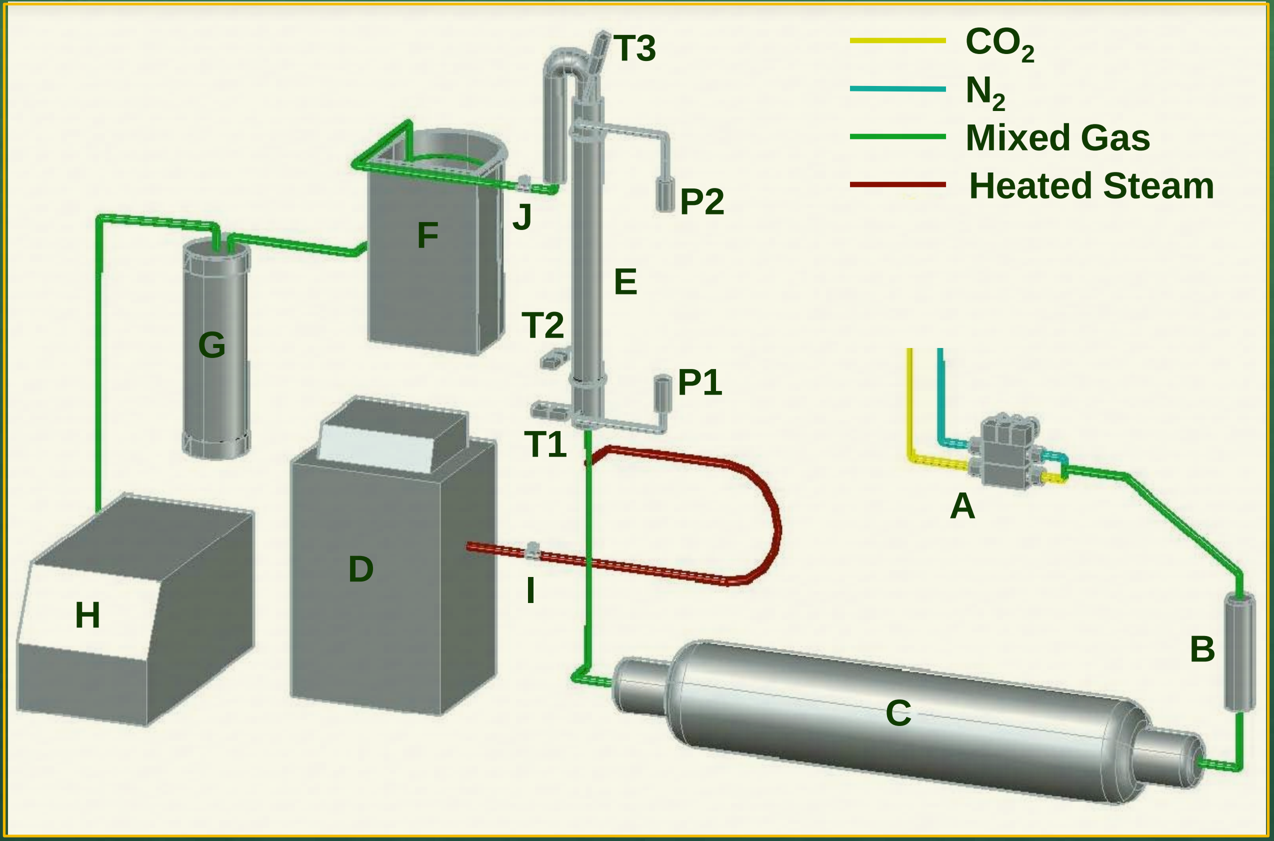
Decision Points and Success Criteria

Decision Point	Basis for Decision/Success Criteria
Completion of Budget Period 1 Year 1	1. Successful completion of all work proposed in Budget Period 1 2. Demonstrate sorbent CO_2 equilibrium capacity of greater than 70 g of CO_2/kg of sorbent 3. Demonstrate a heat of sorption of 80 kJ/mol of CO_2 or less 4. Submission of a Topical Report – Preliminary Technical and Economic Feasibility Study 5. Submission/approval of a Continuation Application to DOE
Completion of Budget Period 2 Year 2	1. Successful completion of all work proposed in Budget Period 2 2. Submission of a bench-scale engineering design package 3. Complete construction of a bench-scale CACHYS™ system 4. Submission of a test matrix for the bench-scale testing campaign 5. Submission/approval of a Continuation Application to DOE
End of Project Year 3	1. Successful completion of all work proposed 2. Complete continuous testing of integrated bench-scale CACHYS™ process for 1 month 3. Submission of a Topical Report – Final Technical and Economic Feasibility Study 4. Submission of a Topical Report – Preliminary EH&S Assessment 5. Submission of a Final Report

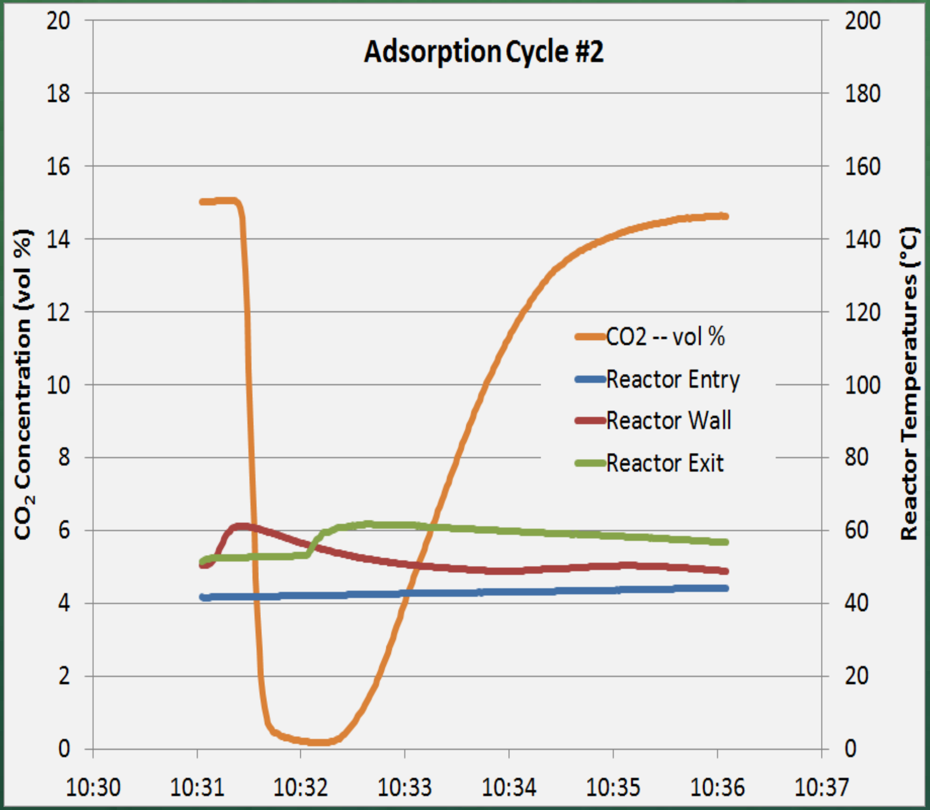
Project Results

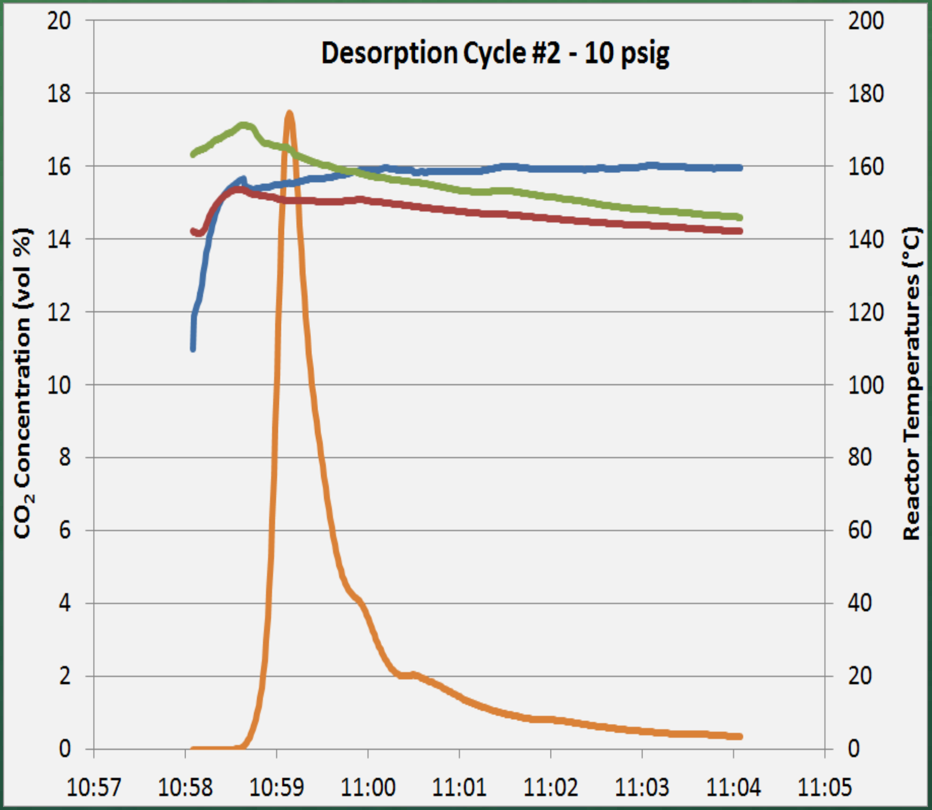
Bed Reactor Testing



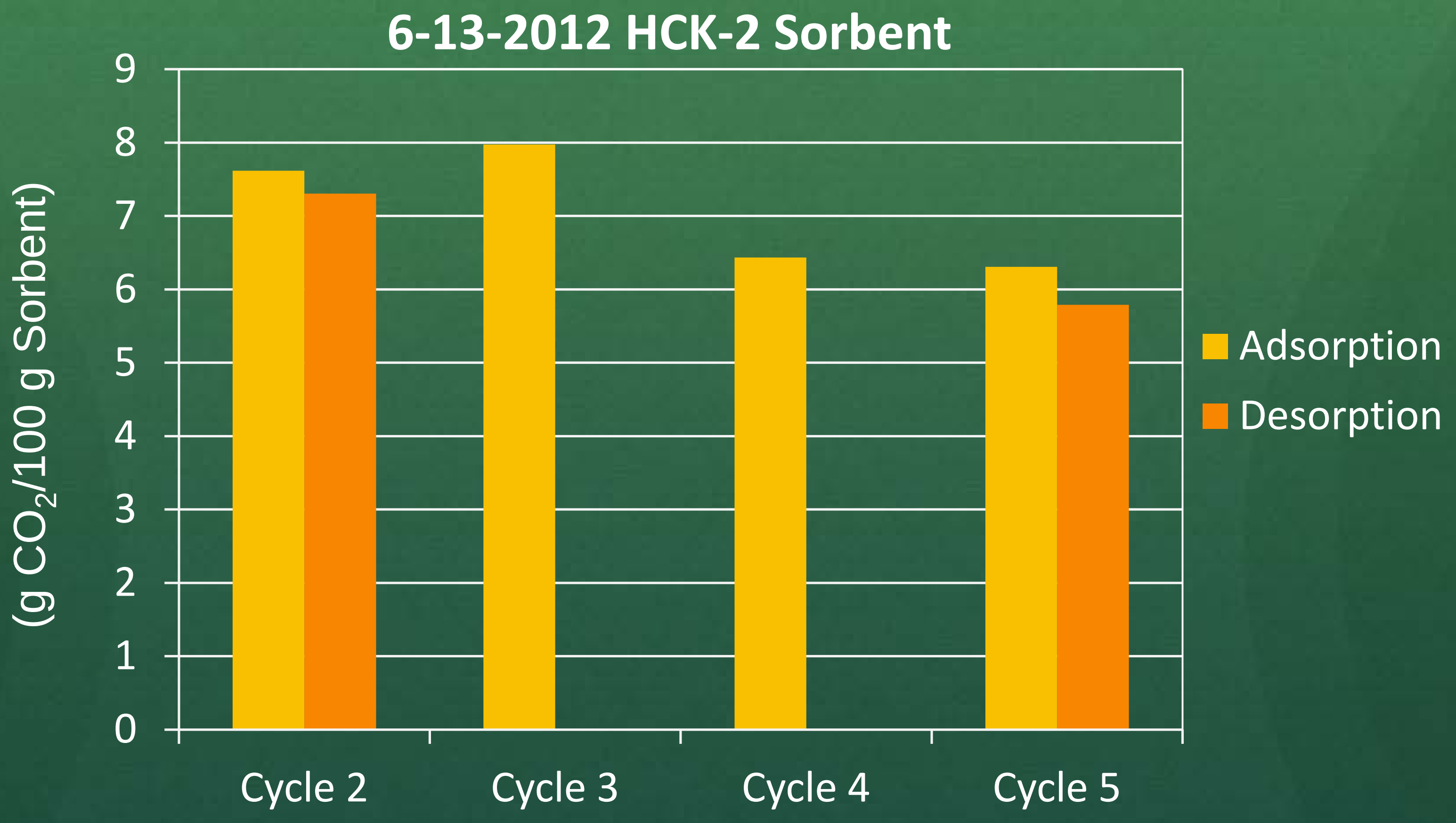
Components	
A	Mass Flow Controllers
B	Bubbler
C	Air Preheater
D	Steam Generator
E	Reactor
F	Condenser
G	Water Knockout Drum
H	5 Gas Analyzer
I	Manual Steam Control #1
J	Manual Steam Control #2
T1	Thermocouple – Air In
T2	Thermocouple – Reactor Wall
T3	Thermocouple – Air Out
P1	Pressure Transducer (Bottom)
P2	Pressure Transducer (Top)

Bed Reactor Testing Results

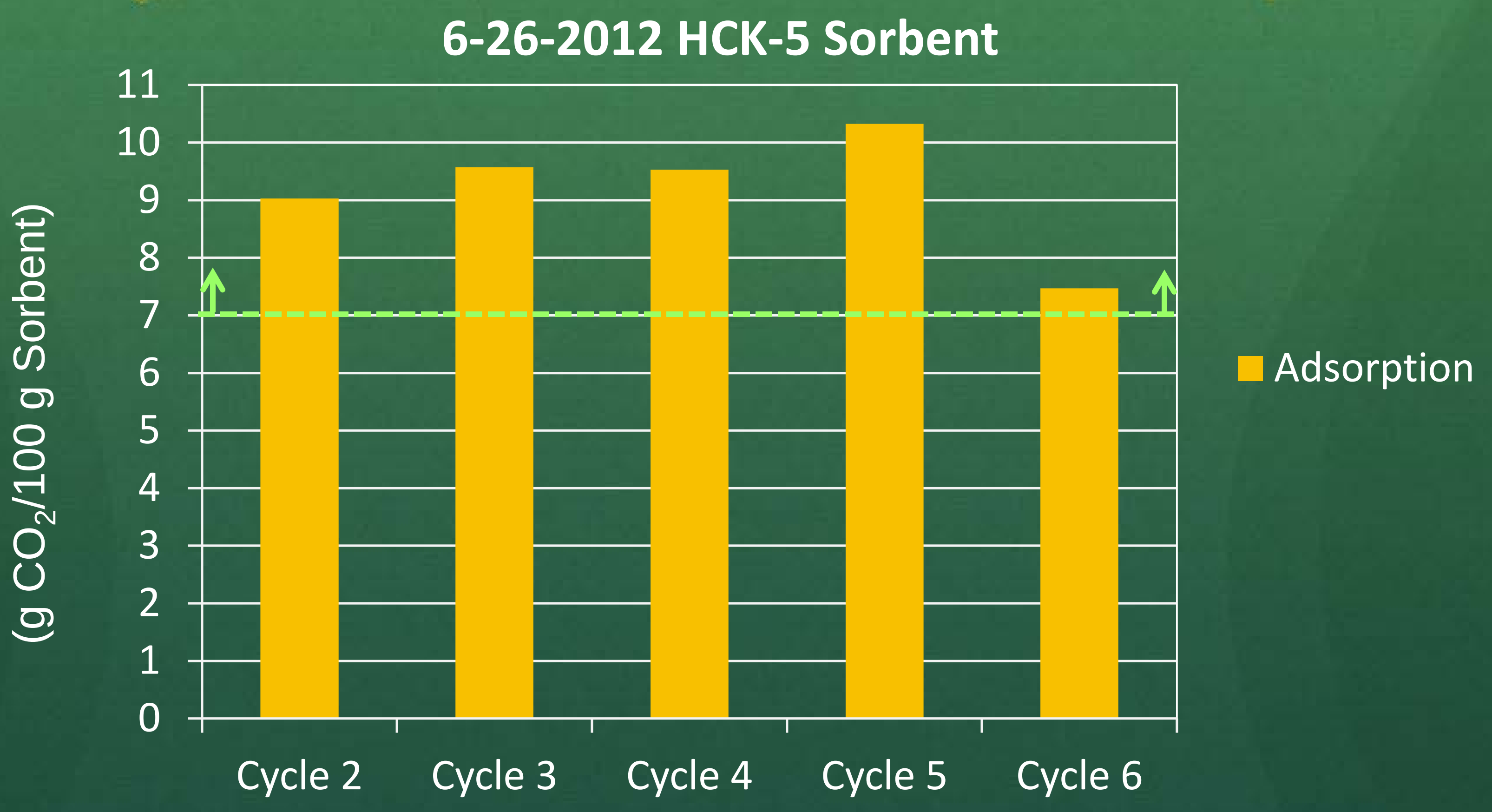




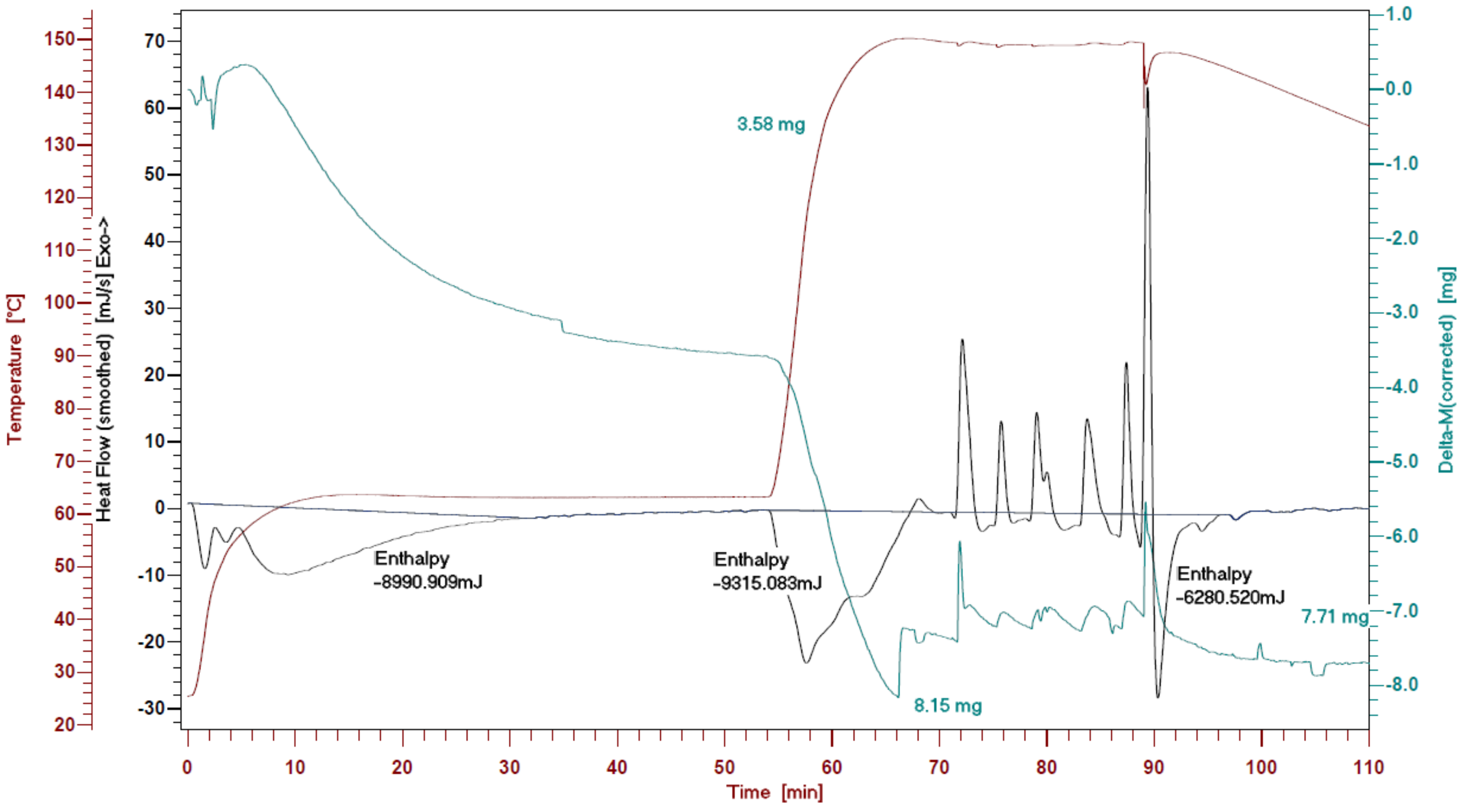
CO_2 Adsorption Capacity



CO_2 Adsorption Capacity



Adsorption-Desorption Cycle: TGA/DSC



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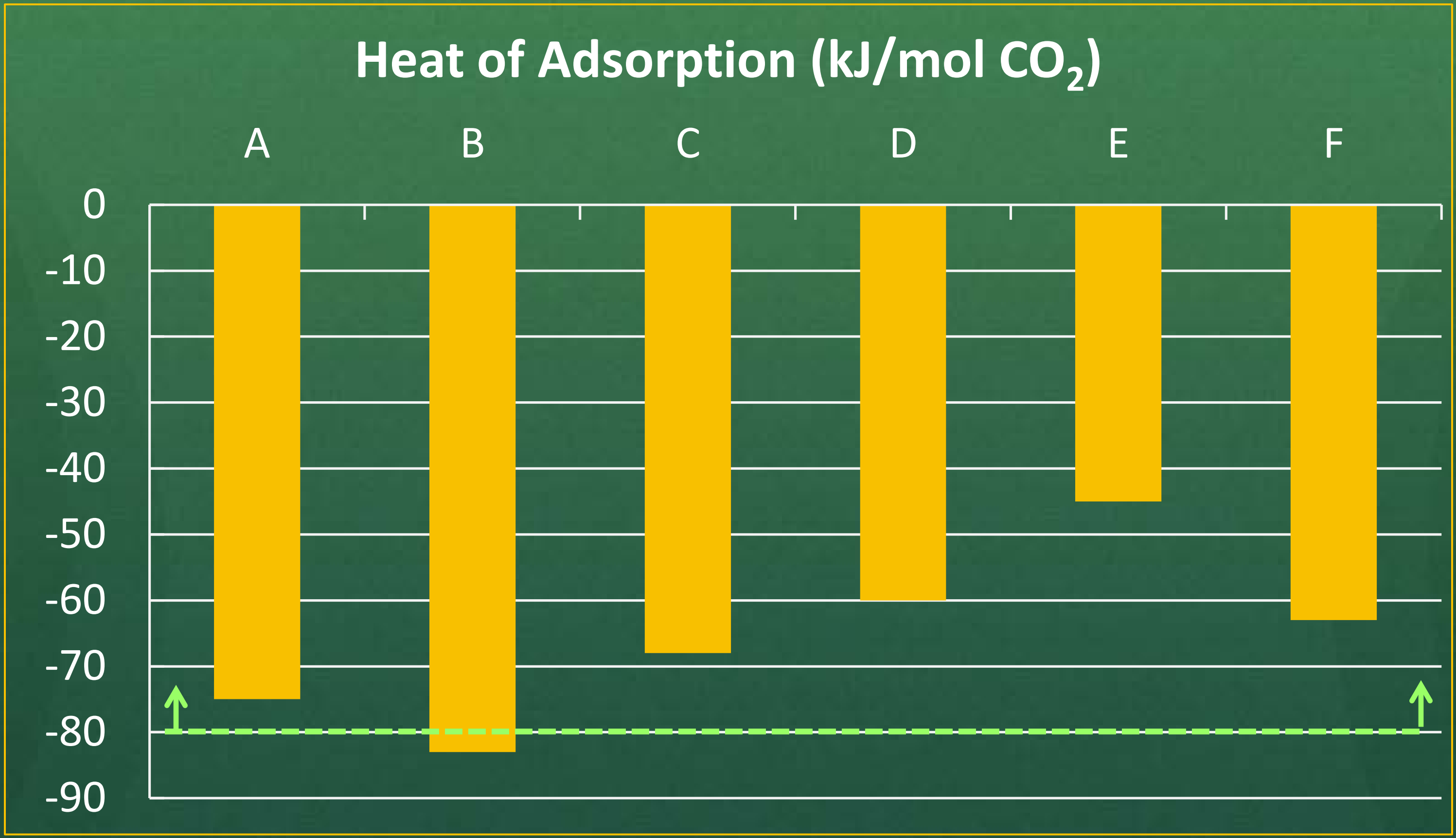
CO_2 Sorption Energetics



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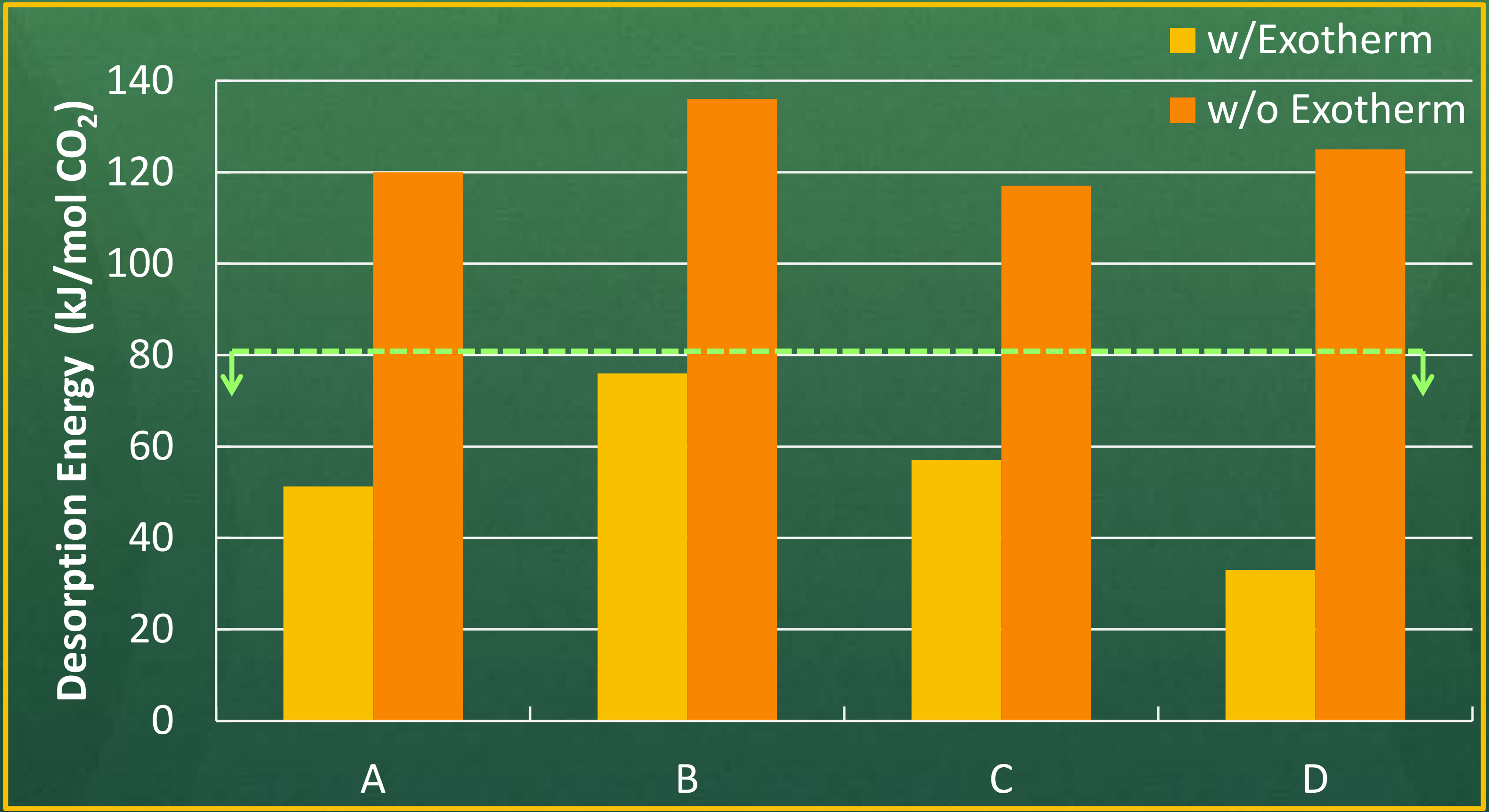

Next Steps

Year 2

- Task 4. Bench-Scale Unit Design
- Task 5. Bench-Scale Unit Procurement and Construction
- Task 6. Initial Operation of the Bench-Scale Unit

Year 3

- Task 7- Bench-Scale Process Testing
- Task 8 - Final Process Assessment

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Acknowledgements

- Project Funding and Cost Share
  - DOE-NETL
  - Lignite Energy Council/NDIC
  - ALLETE (Minnesota Power and BNI Coal)
  - SaskPower
  - Solex
  - UND
- DOE-NETL Project Manager – Andrew Jones

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