Novel Next-Generation Sorbent System for Post-Combustion CO_2 Capture

PROJECT OBJECTIVE

To develop a transformational MOF-based (metal organic framework) CO_2 sorbent system that can:

- Capture more than 90% of the CO_2 emissions from a coal power plant
- Recover CO_2 at 95% purity
- Reduce the cost of capture to ≤ \$30/tonne CO_2 while reducing the cost of electricity by ≥ 30% relative to amine-based capture systems

TEAM MEMBERS

TDA Research

University of Alberta

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Wyoming Integrated Test Center

APPROACH

Budget Period 1

- Demonstrate sorbent performance
- Assess impact of flue gas contaminants (SO_2, NO_x, and HCl)
- Develop adsorption cycle sequence
- Develop preliminary TEA

Budget Period 2

- Scale-up sorbent production
- Complete lifetime tests
- Optimize cycle and update TEA

Budget Period 3

- Complete field tests (6 months)
- High-fidelity TEA and EH&SA

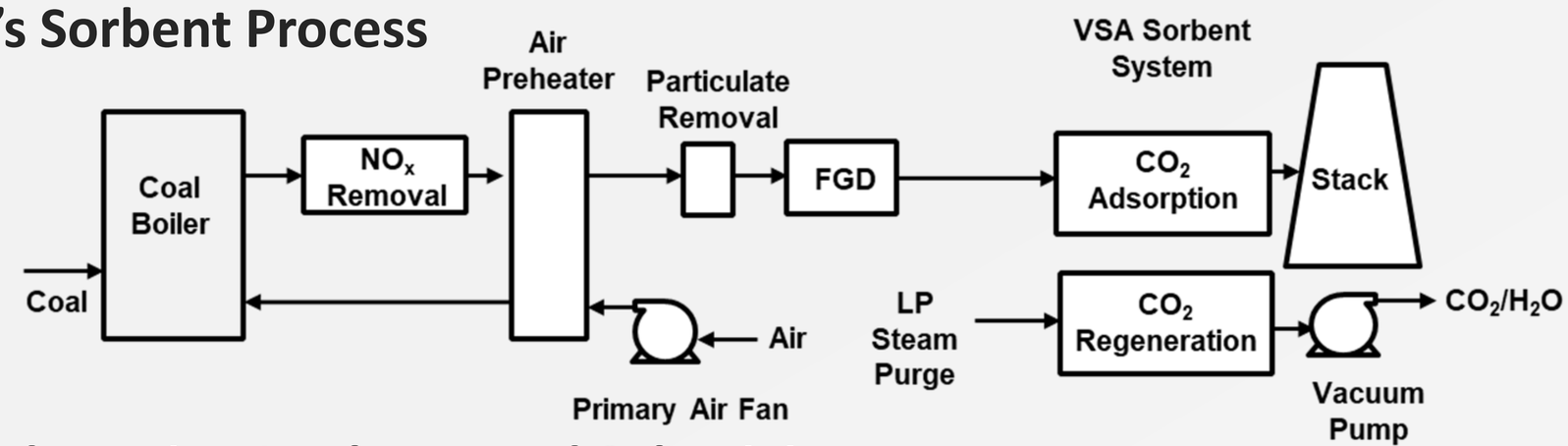
TDA's MOF Adsorbent

- Sorbent has excellent CO_2 uptake kinetics and selectivity; product purity ≥ 95% has been achieved
- Sorbent has demonstrated a CO_2 working capacity ≥ of 4% wt.
- Lab-based testing with flue gas contaminants indicates stable sorbent performance in the presence of SO_2 and NO_x

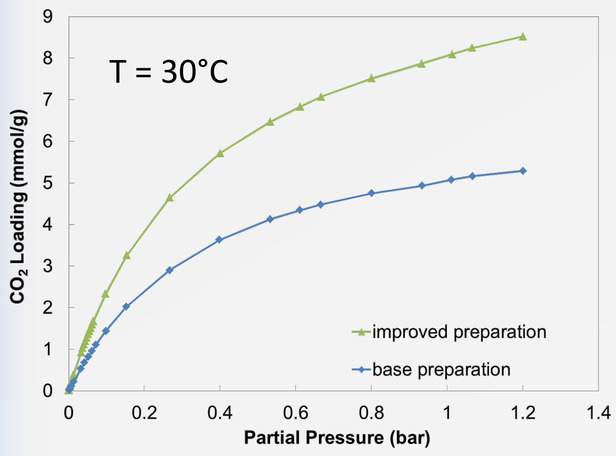
Initial TEA

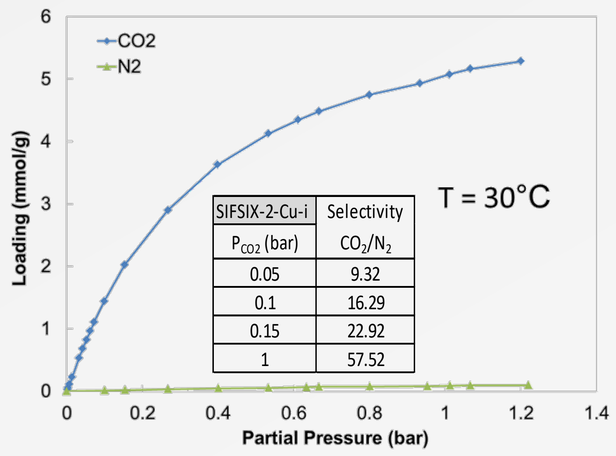
- CO_2 capture consumes ≤ 117 kWh/tonne (242 kWh/tonne when CO_2 compression included)
- Net power output is reduced by roughly 17.4% for a cost of CO_2 capture ≤ \$32.25/tonne
- Reducing CAPEX to \$275 MM can further reduce capture cost below \$30/tonne

TDA's Sorbent Process

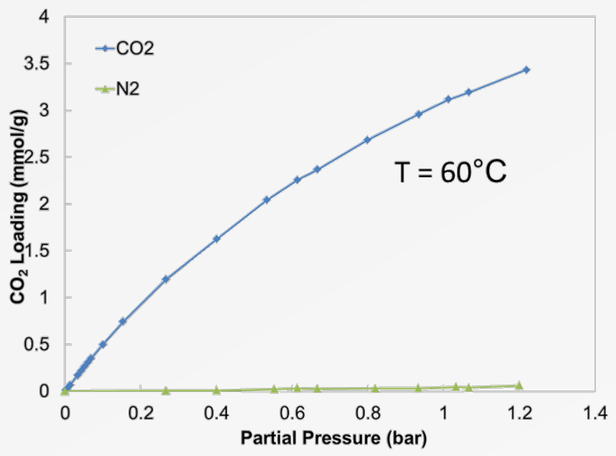


CO_2 Adsorption Isotherm and Selectivity

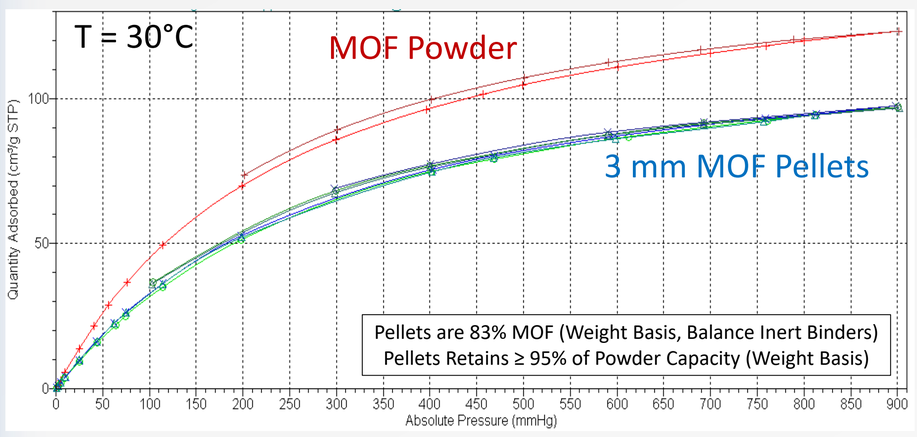




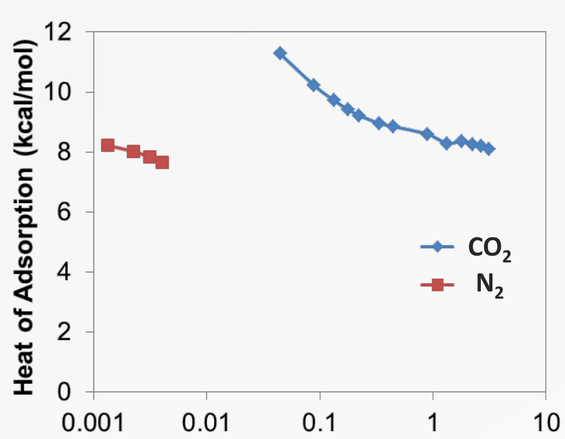
SIFSIX-2-Cu-i	Selectivity
P_{CO2} (bar)	CO_2/N_2
0.05	9.32
0.1	16.29
0.15	22.92
1	57.52



Pelletized MOF Sorbent

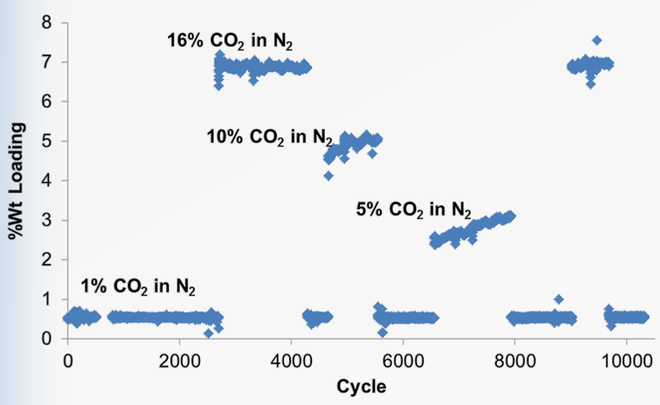


Heat of Adsorption



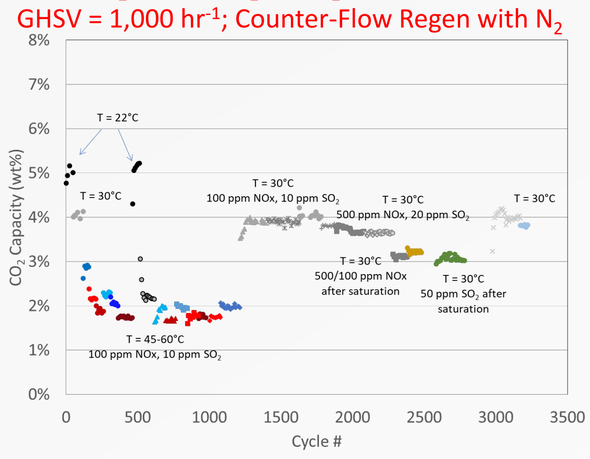
Fixed Bed Reactor Tests

Ads: 1–16% CO_2 in N_2; Des: N_2; T = 28°C



15% CO_2 & 0–6% H_2O in N_2 at T = 30/45/60°C

GHSV = 1,000 hr^{-1}; Counter-Flow Regen with N_2



Preliminary TEA

DOE Rev 4 Basis

Capture Technology	Sorbent Only	Amine	No Capture
Case Studies	Case 1	B12B	B12A
Basis for Cost Estimates (Year)	2018	2018	2018
Net power, MW	650	650	650
Capacity factor (CF), %	85	85	85
Total plant cost (TPC), $	2,053,929,454	2,468,373,000	1,364,033,000
Total overnight cost (TOC), $	2,553,134,556	3,023,049,325	1,678,411,825
Total as spent capital (TASC), $	2,946,317,278	3,488,598,921	1,937,578,752
LCOE	$/MWh	$/MWh	$/MWh
Capital Charge (0.0707 X TASC)	43.04	50.96	28.30
Fixed Charges	13.73	16.13	9.48
Variable Costs	12.15	14.00	7.72
Fuel Costs	22.75	24.08	18.87
Byproducts (Credit)	0.00	0.00	0.00
Total (Excluding T&S)	91.67	105.18	64.37
CO2 T&S Costs	8.45	8.96	0.00
Total (Including T&S)	100.12	114.14	64.37
Cost of Capture	$/tonne	$/tonne	$/tonne
Breakeven CO2 Sales Price (compared to SCPC W/O capture)	32.25	45.52	-
Breakeven CO2 emissions penalty (compared to SCPC W/O capture)	52.29	73.40	-

Wyoming ITC Field Test Unit (2–4 scfm)

TDA's field demo installation near Gillette, Wyoming is designed for continuous, all-season testing with coal-derived flue gas (local PRB coal) at flows of up to 150 scfm.

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