PCI
Precision Combustion, Inc.

High-Efficiency Post Combustion Carbon Capture System
DOE SBIR Phase 1 Contract # DE-SC0017221

Company: Precision Combustion Inc.
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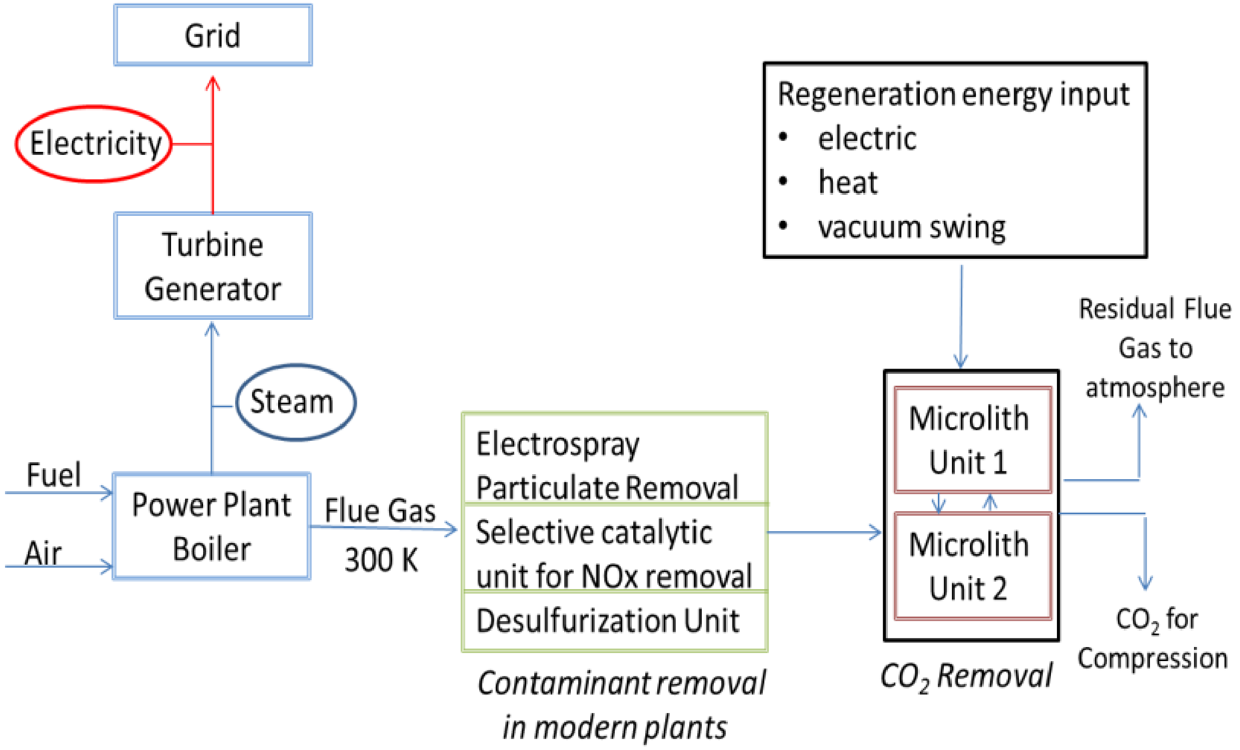
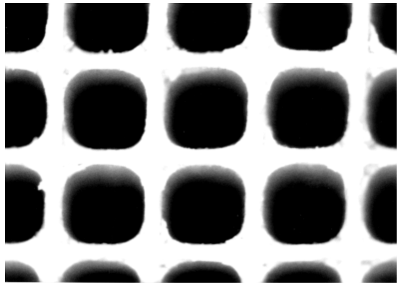
Innovation

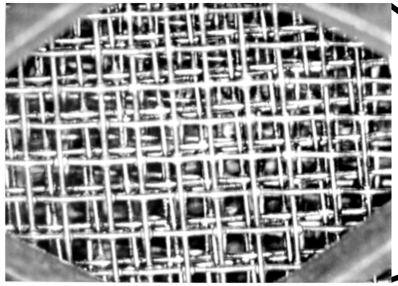


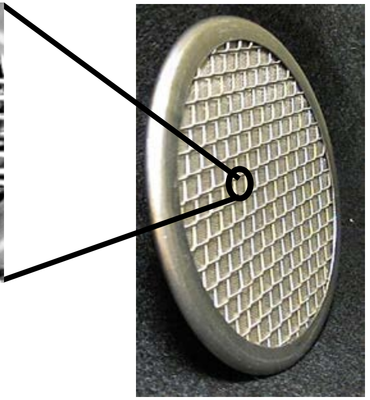
Compact, modular Post Combustion Carbon Capture System utilizing high capacity nanosorbents in a unique lower pressure drop system design that requires less energy to operate and improves capital and operating cost compared to liquid amines removal.

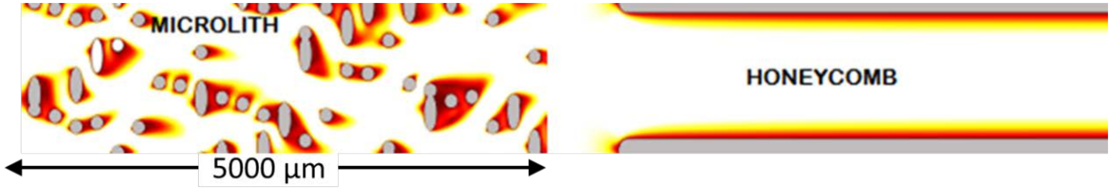
Microlith Substrate

Conventional Monolith		PCI's Microlith Substrate
400	Cells / in^2	2500
2.64	GSA (m^2 / liter)	6.3
3.0 – 5.0	Channel Length (in)	0.003
1200	Material Limit Temp (°C)	1200
70	Frontal Open Area (%)	72









CFD analysis of fluid flow behavior in 2D cross-sections through a stack of 21 Microlith mesh elements (left), a single channel in a honeycomb monolith (right).

Benefits of Microlith® substrate:

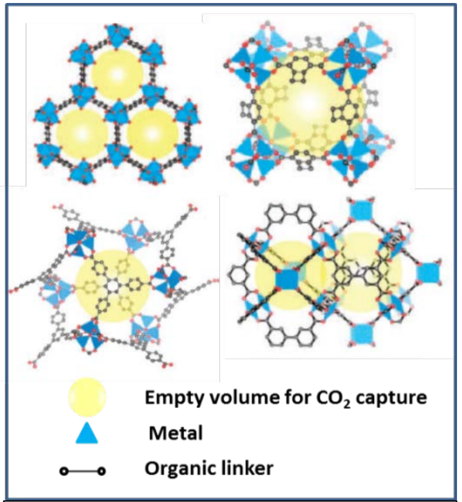
- High surface area per unit volume
- High heat & mass transfer rates
- Low sorbent usage & small size
- Lower ΔP vs. pellet sorbent bed
- Comparable ΔP vs. monoliths
- Design flexibility (e.g., planar, radial)
- Modular design, easily scalable
- Resistive heating

Choice of sorbent

Selection criteria

- Minimize energy required for sorption/desorption.
- Ability for large-scale production.
- Sorbent composition includes building blocks that are not overly expensive or rare.

Metal Organic Framework (MOF) materials are crystalline organic-inorganic compounds formed by coordination of metal clusters or ions with organic linkers – usually bivalent or trivalent aromatic carboxylic acids or nitrogen-containing aromatics. They have extremely high surface area, high pore volume, uniform size pores, and high metal content making them excellent candidates for selective CO_2 capture.



Structure of MOF materials depicting available volume for CO_2 capture.

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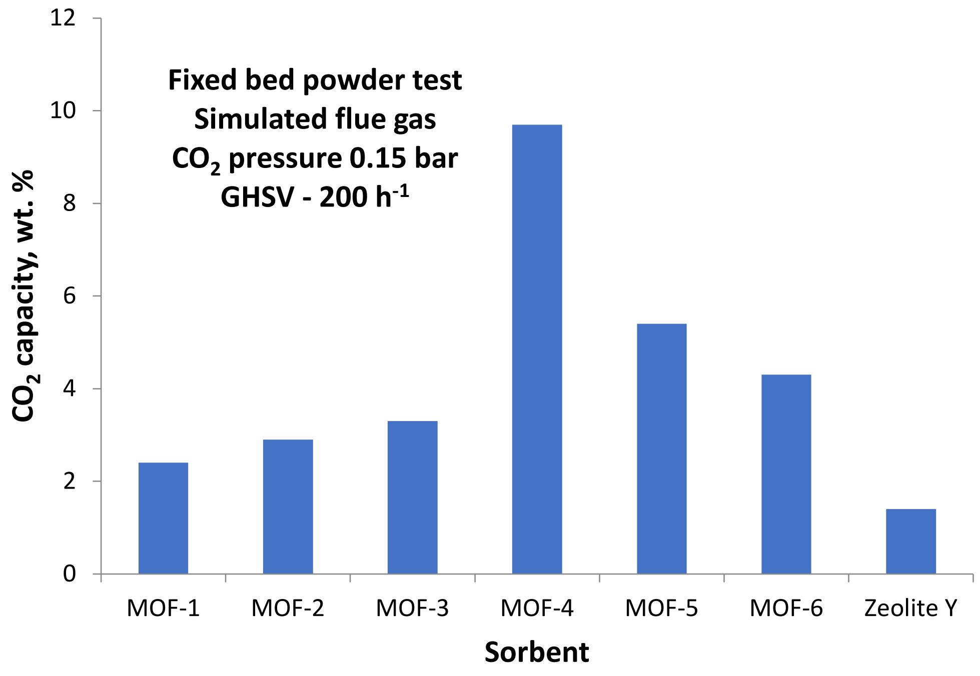
Phase I accomplishments

- Analyze a variety of sorbents produced at the large scale and with potential for low-cost, high-capacity supply.
- Demonstrate coating techniques for sorbents on Microlith metal mesh.
- Demonstrate capacity for CO_2 sorption and regenerability on lab-scale Microlith-based system.
- Demonstrate pathways for significantly reducing the regeneration energy component of total parasitic energy for CO_2 capture, transport and storage.
- Initiate ASPEN modelling of scaled-up Microlith unit with thermal regeneration for integration with the DOE CCSI software.

Sorbent Screening

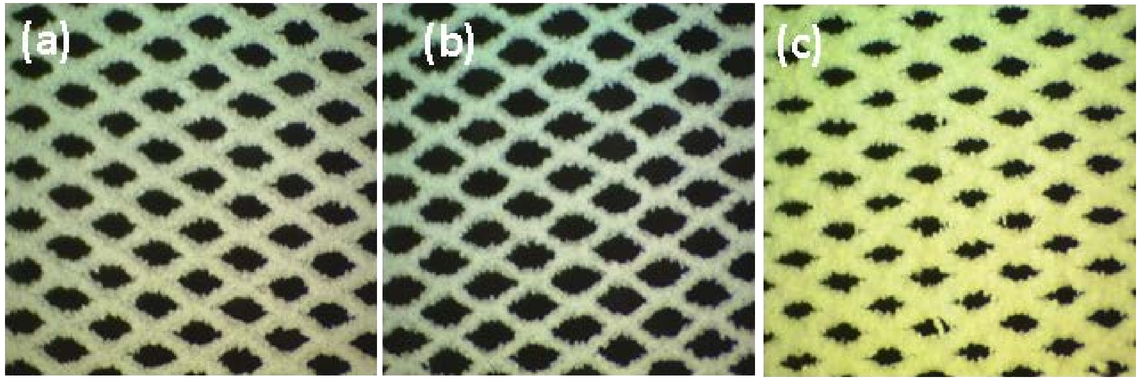


Maximum capacity recorded for each MOF column breakthrough experiments in powder bed.

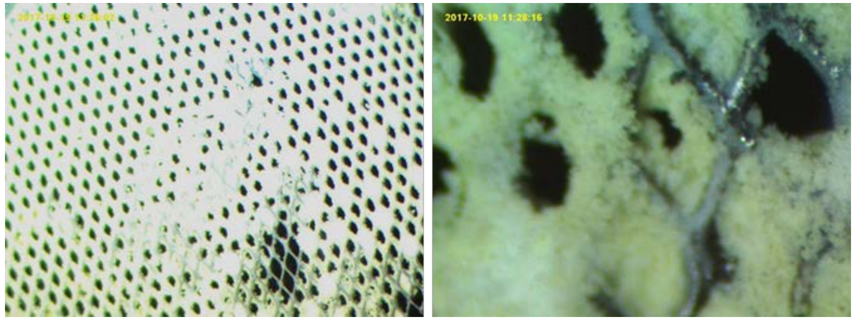
Coating process development

- Coating process is applicable to multiple sorbents to account for new sorbents being developed

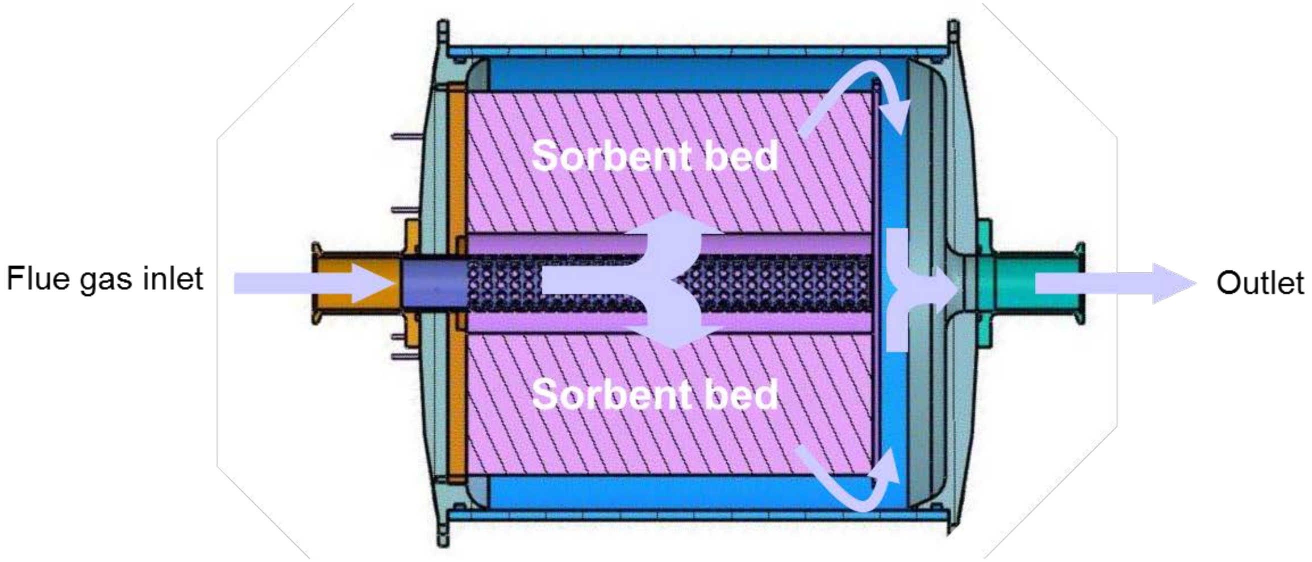
Micrographs of *coated Microlith mesh: (a) zeolite(b) MOF-1(c) MOF-4.*



Failed coating trials for comparison



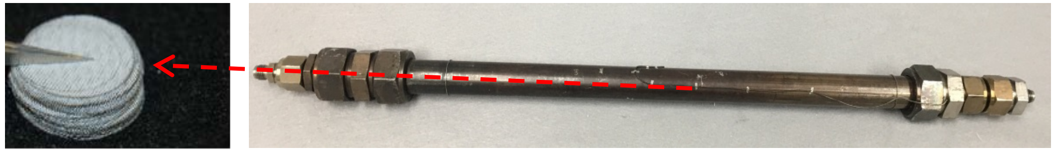
Adsorber Module Design



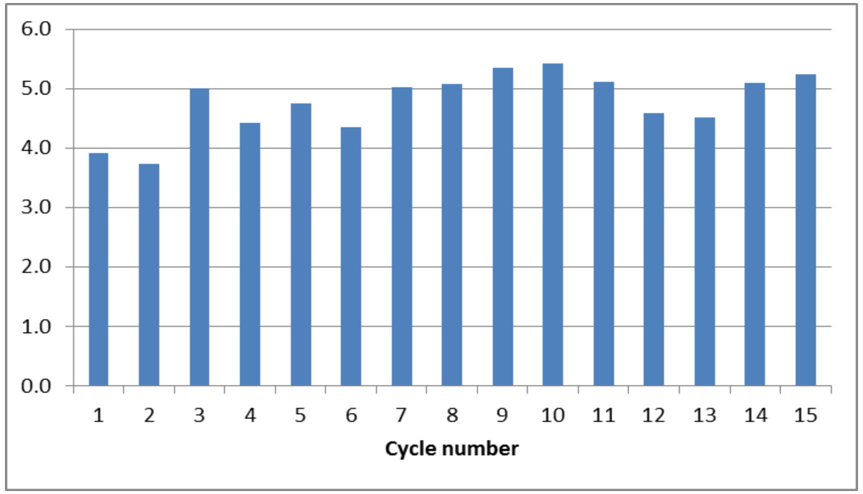
- Sorbent bed consists of coiled layers of Microlith coated with sorbent.
- Ability to coat different sections of mesh w. different sorbents.

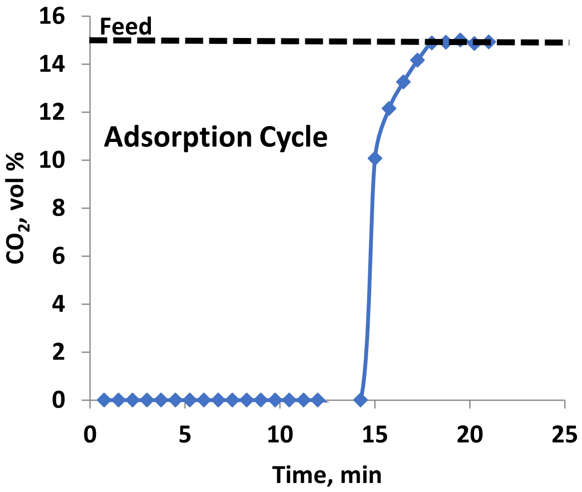
MOF/Microlith test results

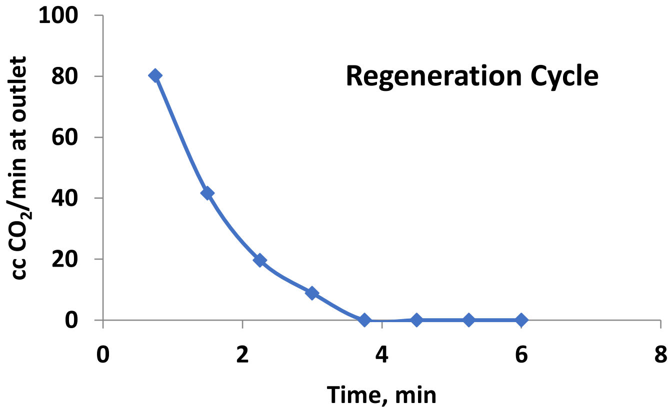
Test assembly for MOF coated on Microlith mesh.



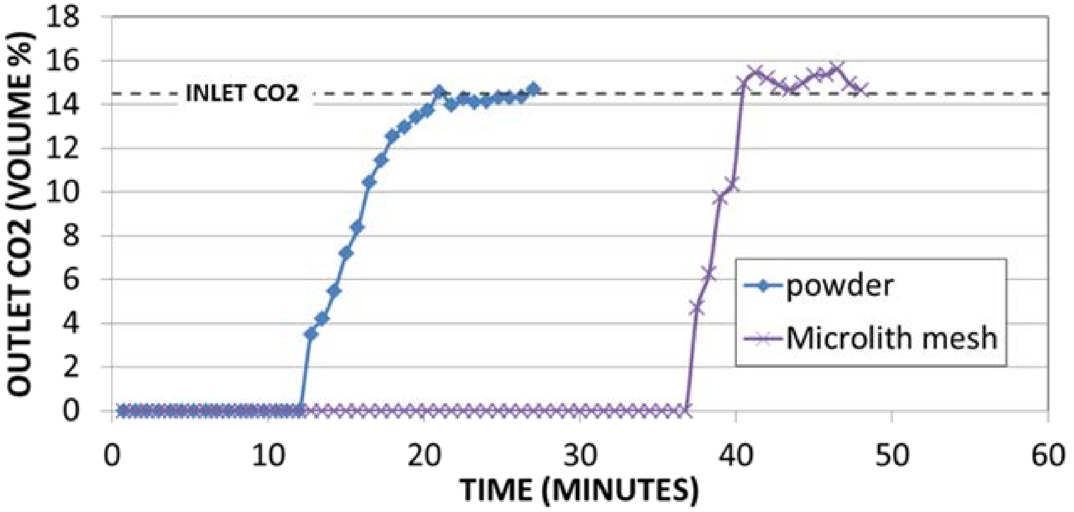
Stable performance over 15 cycles at same GHSV as the powder tests with 55mg/in^2 loading.



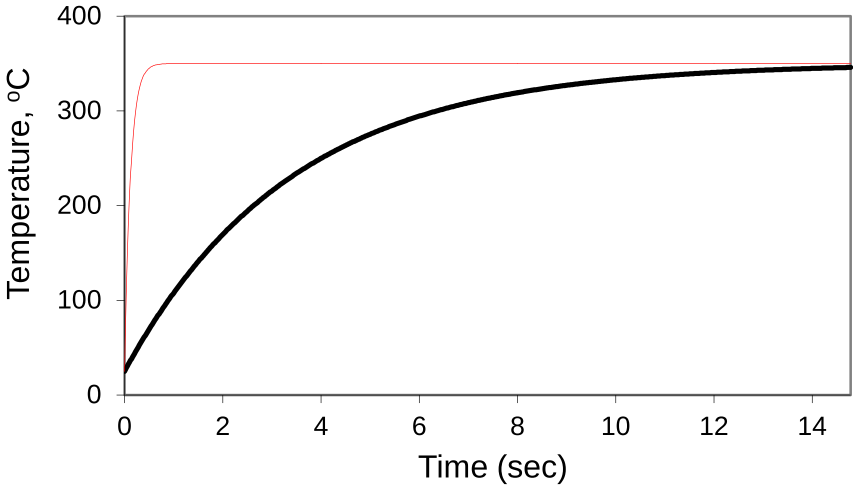




Advantages of Microlith Substrate



Sorption half cycle CO_2 breakthrough curves for powder bed or coated Microlith mesh, both using SIFSIX MOF, measured at 200/hr space velocity, based on sorbent volume.



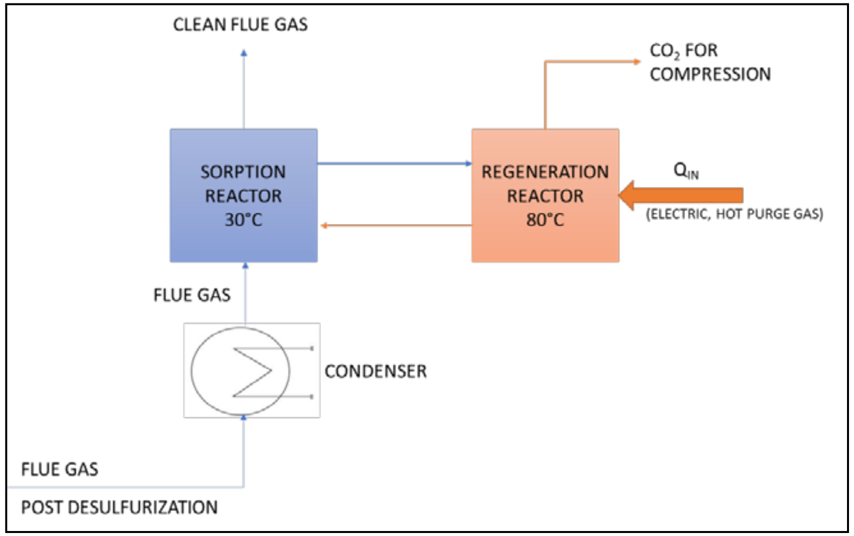
Thermal response prediction of Microlith (red) vs. ceramic monolith (black) in a non-reacting gas at 350°C.

Regeneration energy TSA process

Focused on the regeneration energy term of the total parasitic energy
Assume that the cost of compression is independent of the CO_2 capture method – minimum compression work for a multi-stage compressor with max pressure ratio between each stage of 2.5 and cooling in-between estimated at around 350 kJ/Kg CO_2 *(Ntimaoh et. al. Energy Environ Sci., 2014, 7, 4132)

Depending on on-site conditions:

- Use cheaper low grade thermal energy or waste heat recovered from flue gas cooling.
- Resistive heating of Microlith mesh .



Phase II optimization targets:

- CO_2 storage capacity for MOF - 15 wt. %
- Loading of 150 mg/in^2

Calculated regeneration energy:
Thermal swing with waste heat recovery and CO_2 purge: **270 kWh/ton CO_2.**
Electric swing with mesh resistive heating: **150 kWh/ton CO_2.**

Depending on energy cost (waste heat could be as low as 0.012 $/ kWh – i.e. 3-4 $/ton CO_2)
Electric is easier to integrate but more expensive (up to 0.06$/kWh if we wave transmission costs – 9$/ton)

Liquid amine CO_2 recovery **1100 kwh/ ton CO_2** due to steam injection and water content of amine solution.

Acknowledgements

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