Innovative Materials & Processes for Advanced Carbon Capture Technology (IMPACCT)

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ARPA-E Program Director

NETL CO_2 Capture Technology Meeting

August 22, 2011

Accelerated CCS adoption requires reduction of parasitic loads

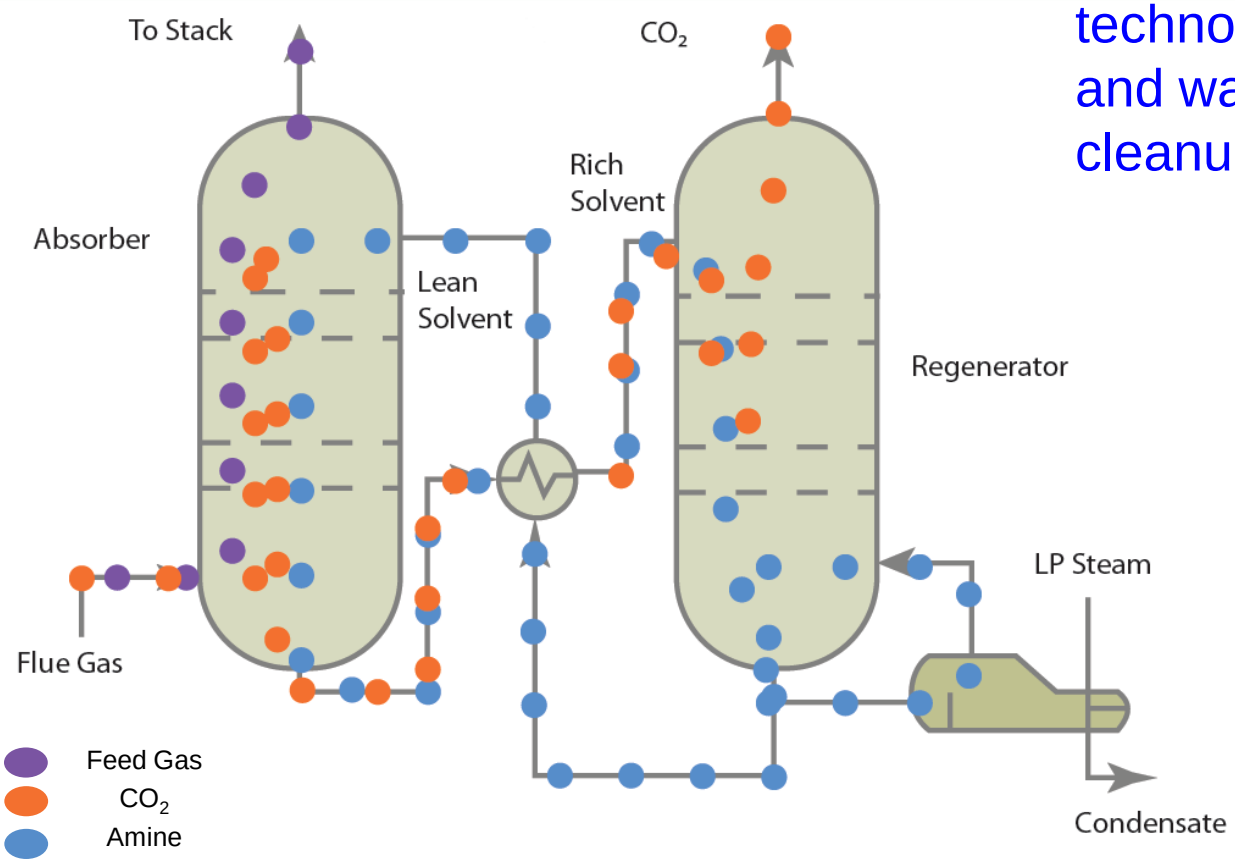


Figure courtesy RTI International

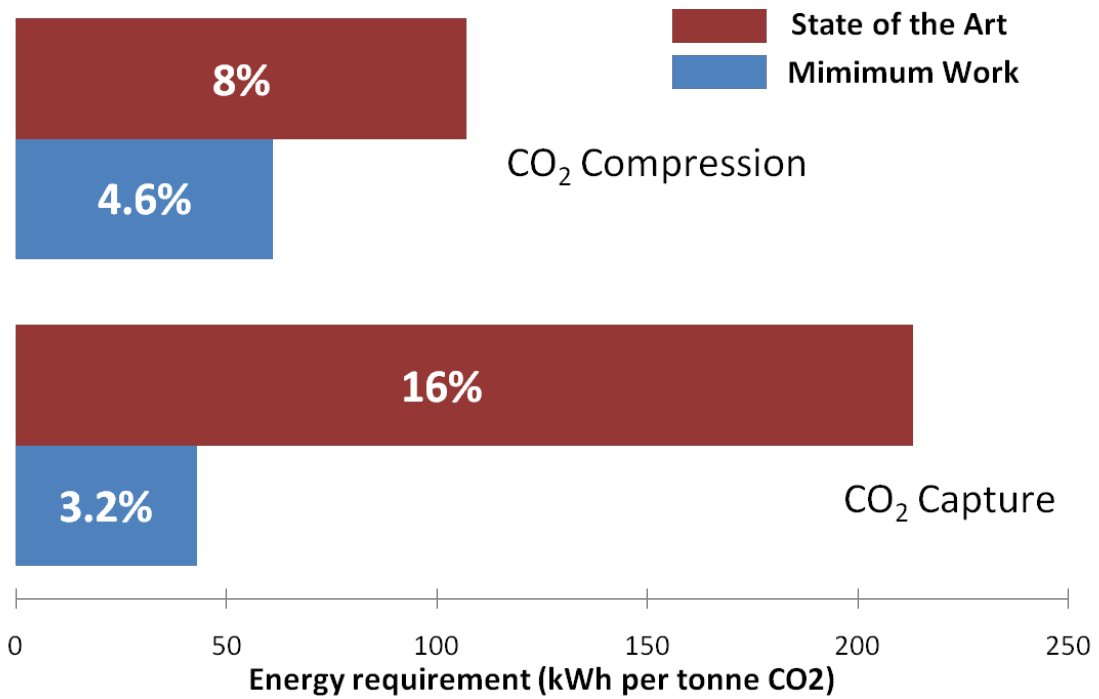
State-of-the-Art amine technology heats a lot of water and was developed for gas cleanup originally

- 25-35% parasitic power load
- \$70-90/ton CO_2
- Levelized cost of electricity increases by ~ 80%

IMPACCT focuses on the energy requirements of post-combustion CO_2 capture

Capture	Compression	Transport	Storage
Post Combustion Oxy-fuel Pre Combustion		Pipelines Tankers	Saline Aquifers EOR Deep Sea

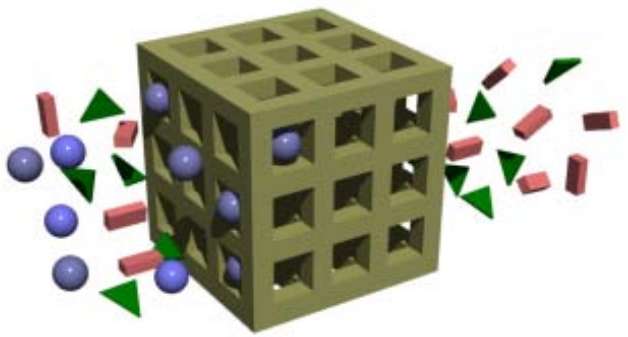
Energy comparison, with parasitic load %



Adapted from Herzog, Meldon, Hatton, *Clean Air Task Force* (2009)

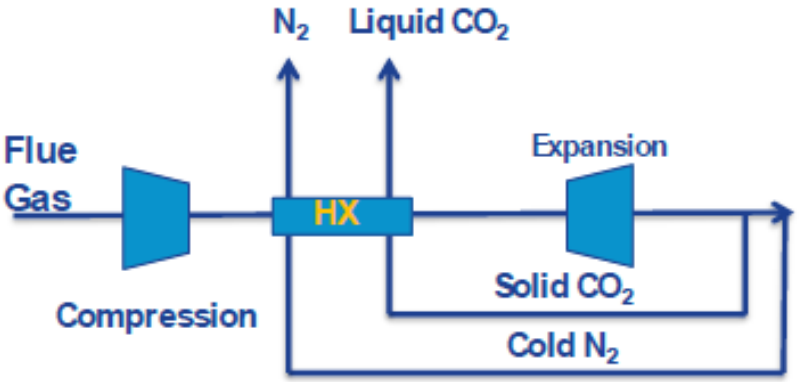
Two approaches toward drastic reduction of energy penalties for CCS

Advanced Materials



LBNL

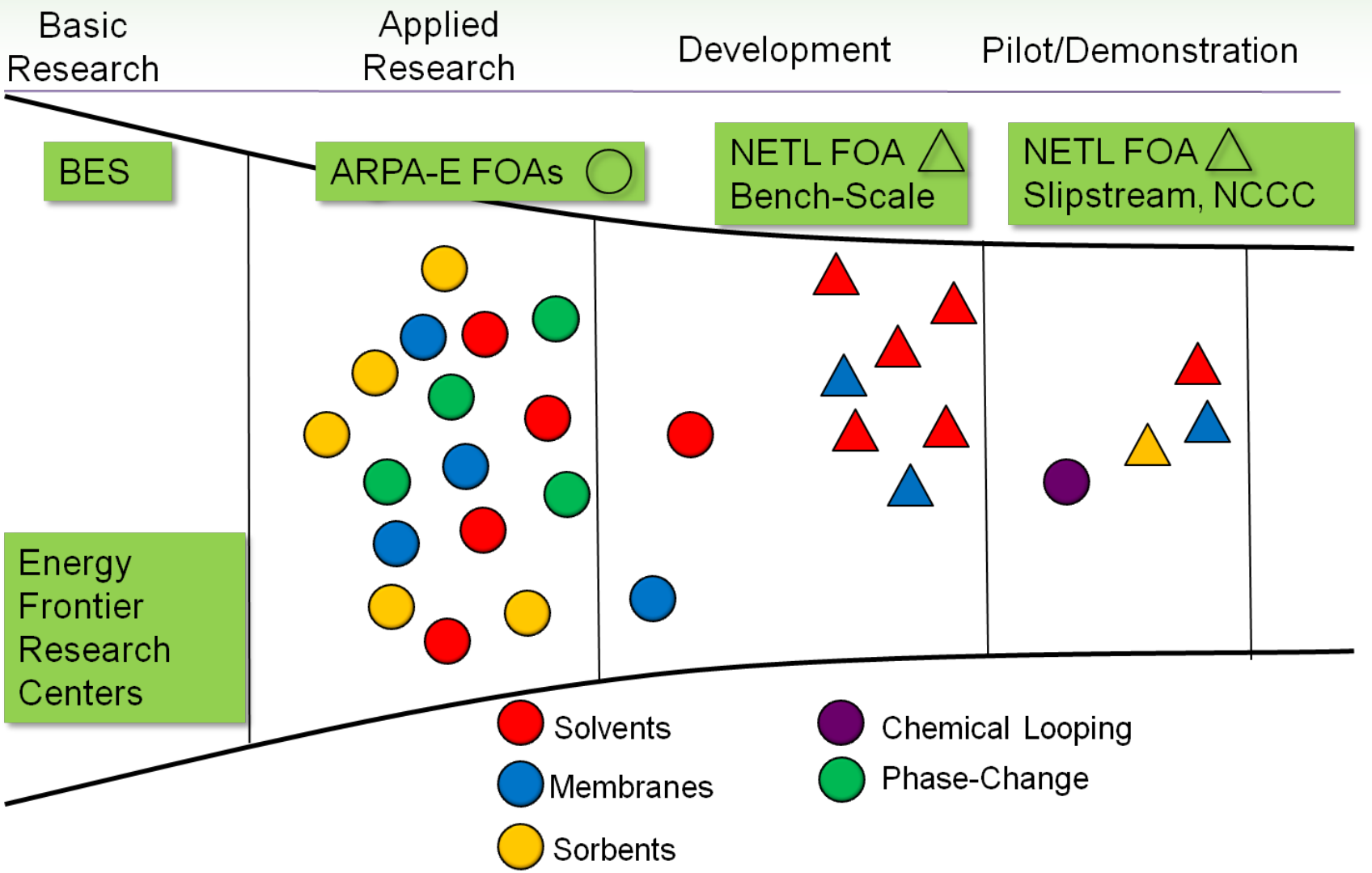
Innovative Processes



SES

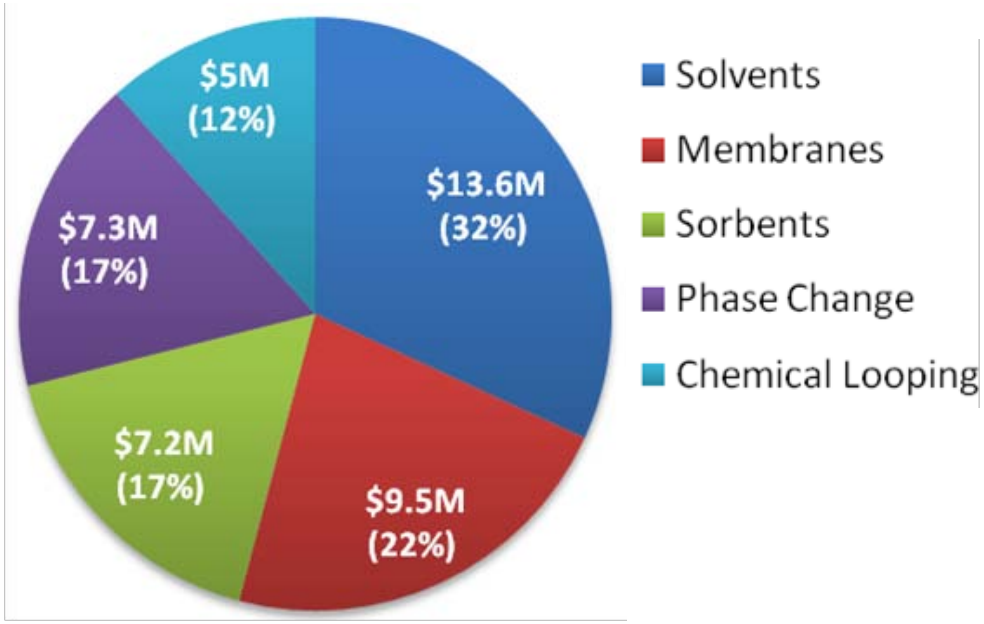
High risk, high reward projects that can disruptively lower the energy needs & cost structure for capture

IMPACCT is expanding early-stage pipeline of new ideas in five technology areas

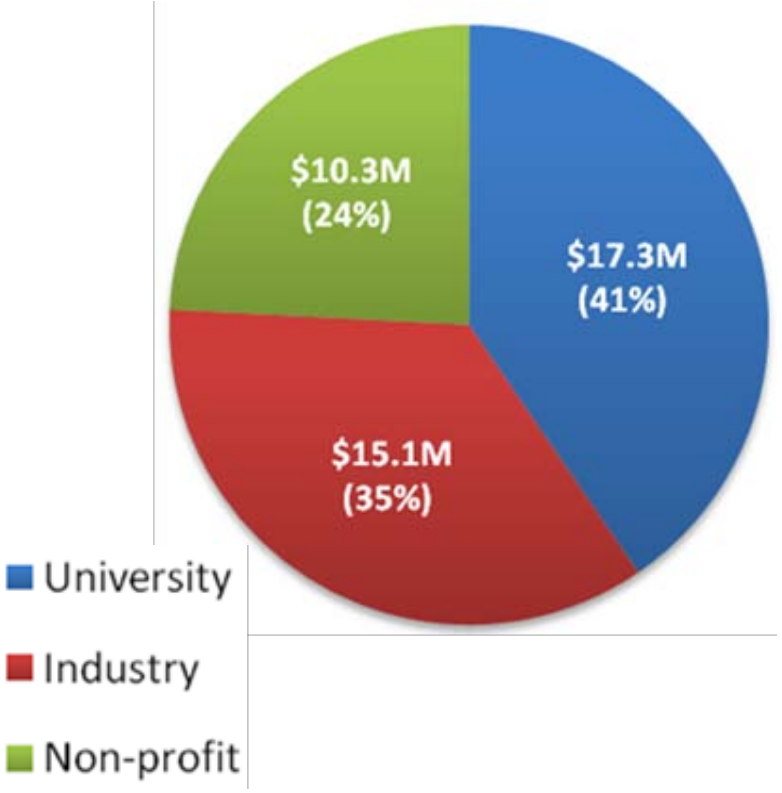


Carbon capture projects from FOA-1 and IMPACCT: $42.7M in federal funding / $58M total

Funding by category

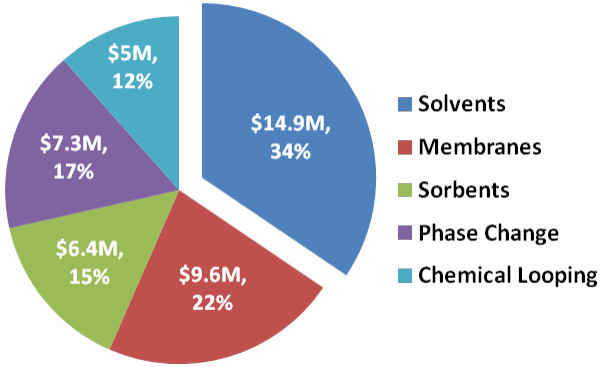


Funding by entity type



Solvent and catalysts

Entity Name	Description
Nalco	Resin wafer electrodeionization
Codexis	**Low-cost biological catalyst***
LLNL	Catalytic improvement of solvent capture systems
Columbia	Catalytic enhancement of weathering of silicate minerals
RTI	Non-aqueous CO2 solvent-based capture process



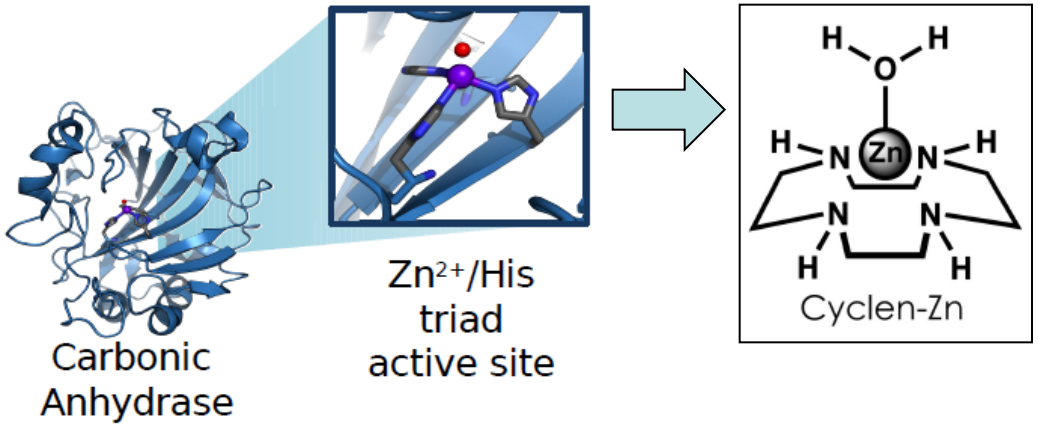
**Blue projects are separate talks on Tuesday afternoon.*

Catalytic improvements of solvent capture systems

Team	**LLNL**, UIUC, B&W			PI	Dr. Roger Aines
Federal funding	3,332,000	Project start	8/15/10	Likely project end	8/14/13

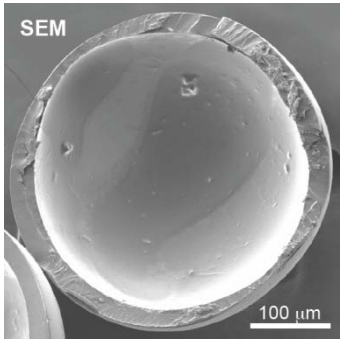
Synthetic Mimics of Carbonic Anhydrase

Retain key features of enzyme without the loss of function in challenging conditions.

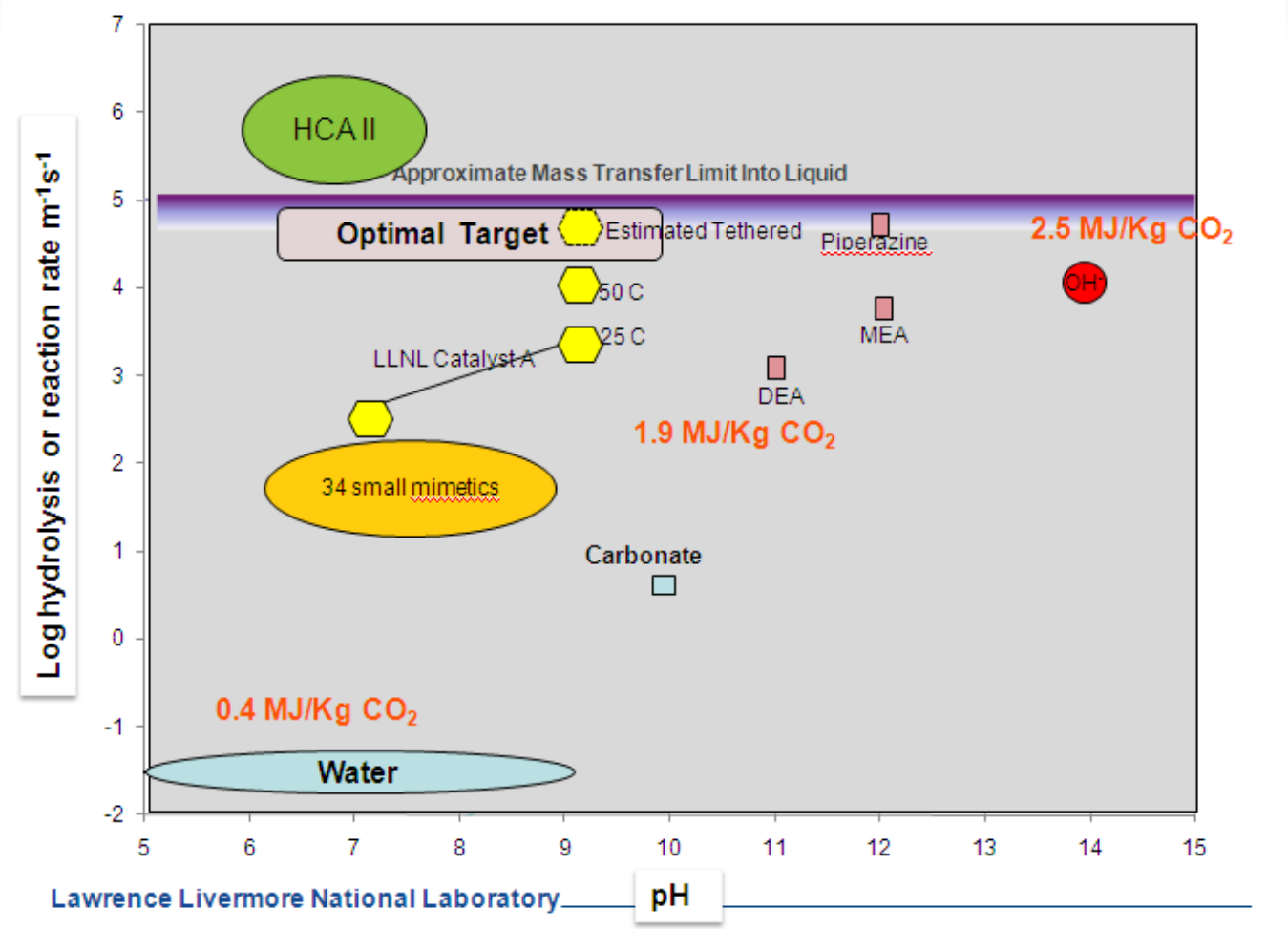


Encapsulation of Solvent

Enables use of more challenging solvent systems, e.g. conc. MEA.

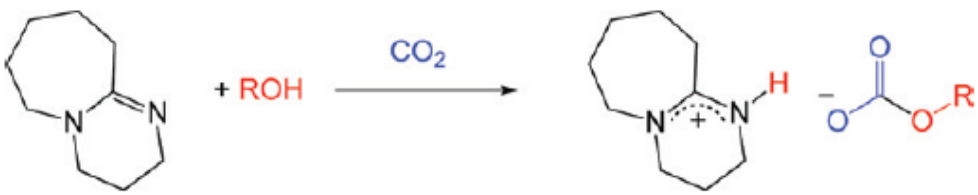


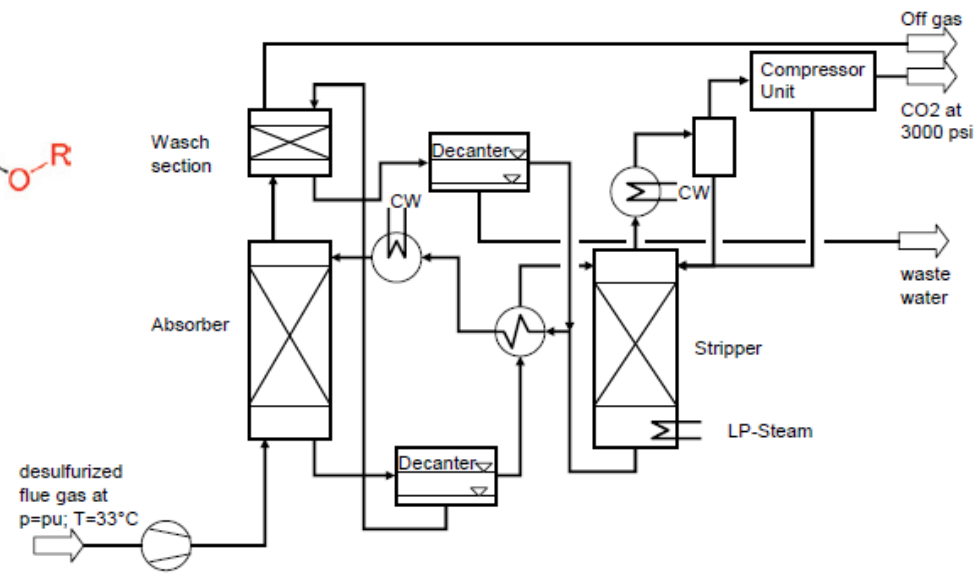
LLNL results



CO_2 capture process using non-aqueous solvents

Team	RTI, BASF			PI	Luke Coleman
Federal funding	2,200,000	Project start	7/1/10	Likely project end	6/30/13



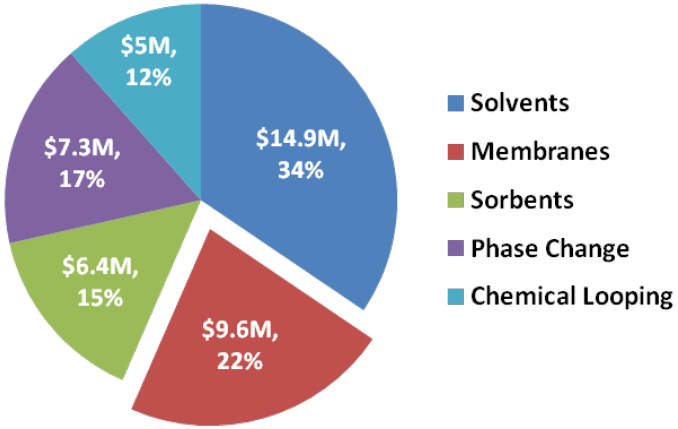


Key Advantages:

- Non-aqueous solution reduces regeneration T to 80°C
- Water phase separates and can be decanted

Membranes

Entity Name	Description
Porifera	Carbon nanotube membranes
UTRC	CA synthetic analogue in polymer membrane
Kentucky	Solvent/Membrane Hybrid PCCC Process
Georgia Tech	MOF/polymer composite membranes
Univ. Colorado	**Gelled Ionic Liquid-Based Membranes**

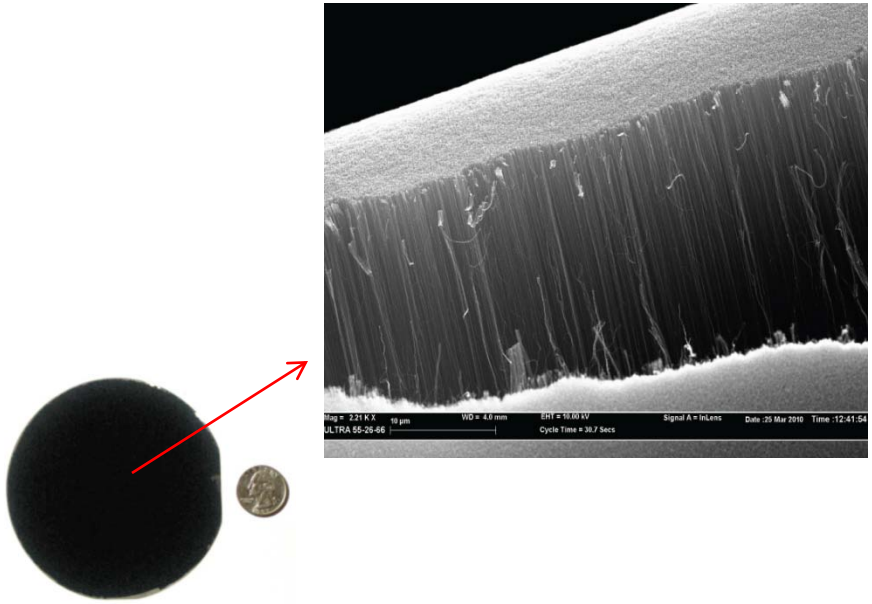


Porifera overview

Team	Porifera				PI	Aleksandr Noy
Federal funding	1,153,975	Project start	3/1/10	Likely project end		2/29/12

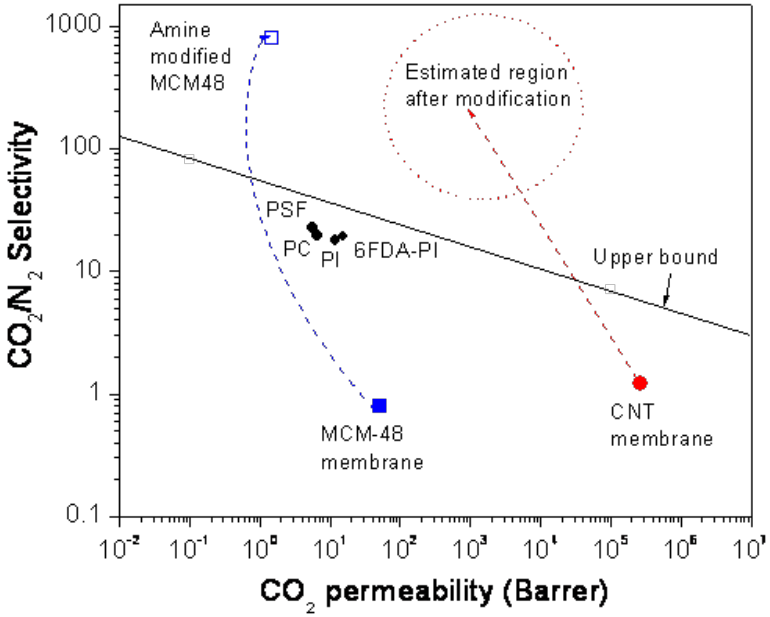
Carbon Nanotube Membranes

High permeability and thermo-chemical resistance makes them good candidates.



Vision Upon Start

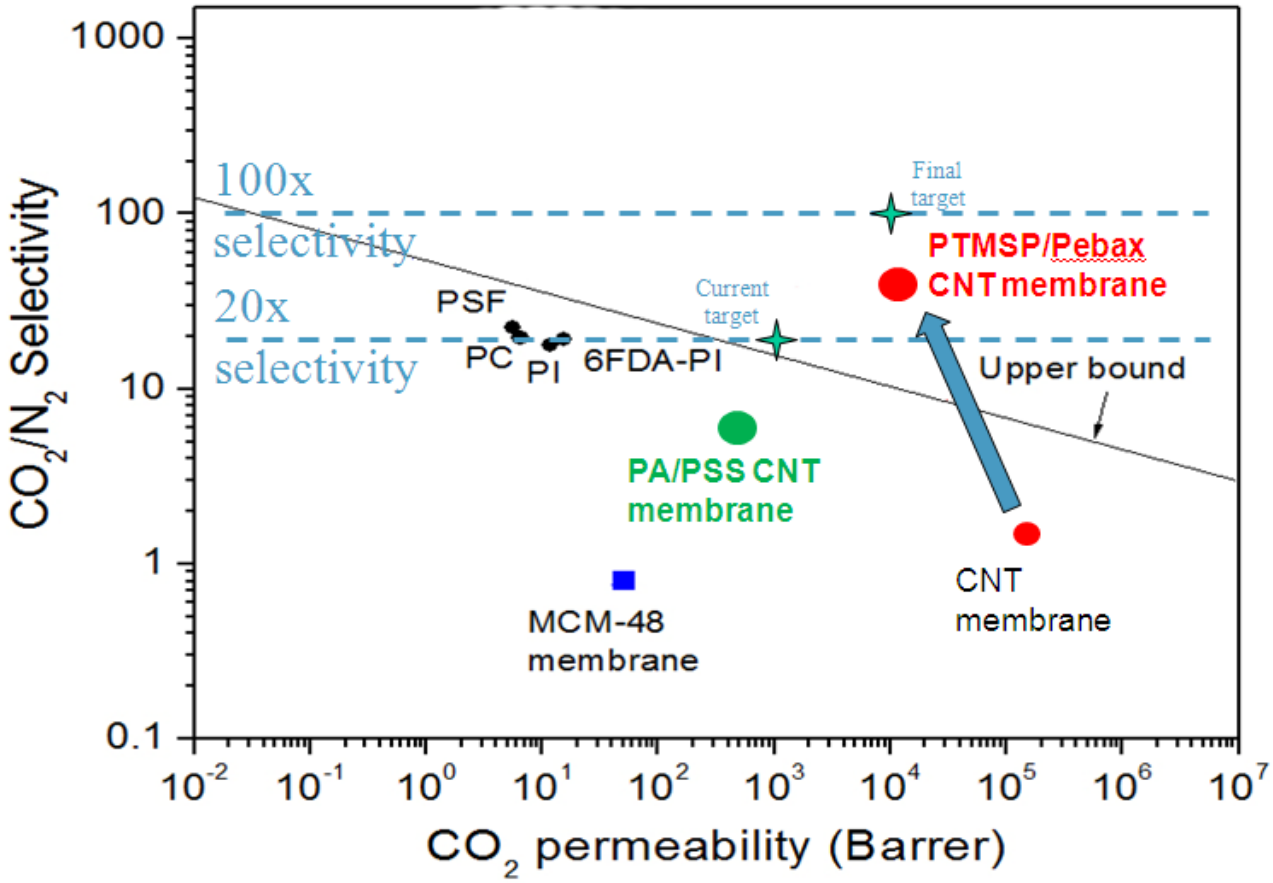
To modify CNT membranes to enhance selectivity similar to the MCM-48 membranes



Porifera results

Successful demonstration of methodology

Modified CNT membranes are in a favorable range of perm-selectivity.

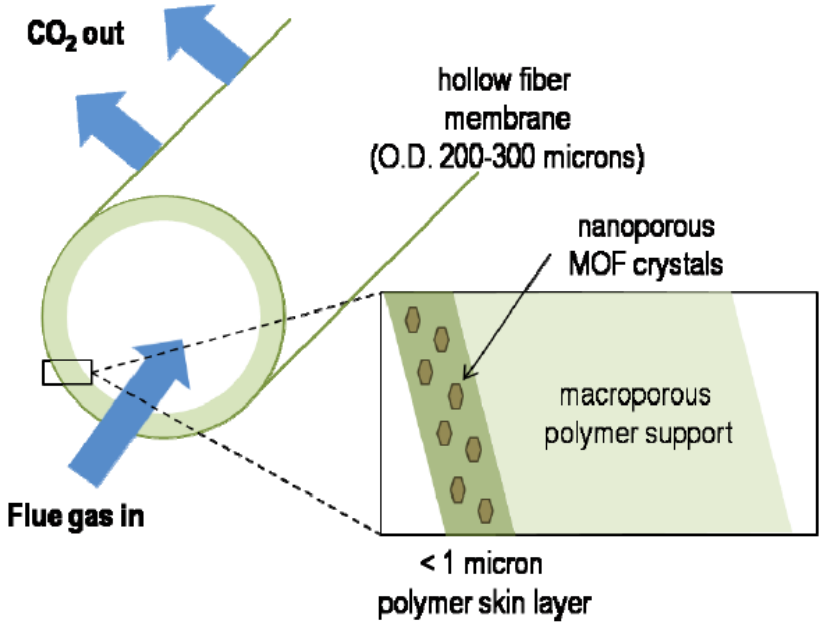


High performance MOF / polymer composite membranes for carbon dioxide capture

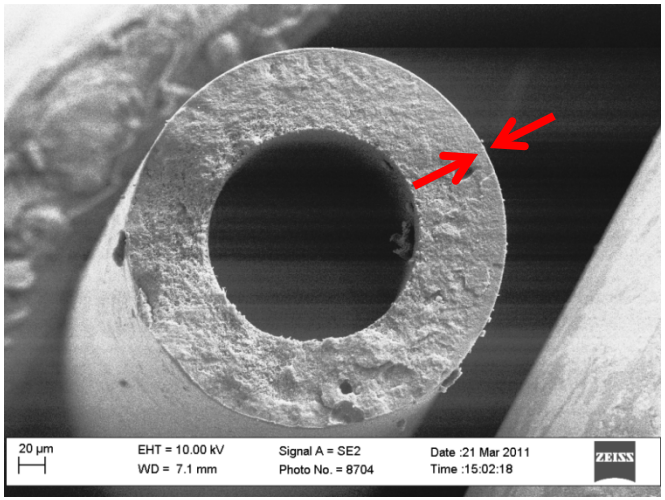
Team	Georgia Tech			PI	Prof. David Sholl
Federal funding	$1,000,000	Project start	07/01/10	Likely project end	06/30/12

MOF Layer Advantage

Pore size distribution and molecular interactions tuned to enhance selectivity.



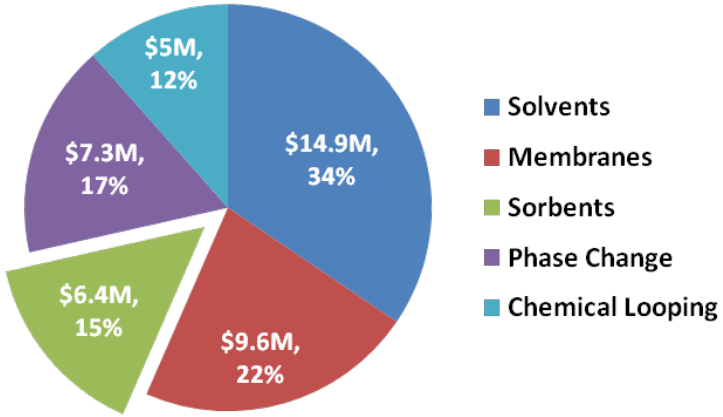
ZIF-8/Ultem membrane



Sample	Permeability (barrers)	CO_2/N_2 Selectivity
Pure Ultem film	3.8	25
10wt% ZIF-8 with Ultem	5.1	28
20wt% ZIF-8 with Ultem	13	30

Sorbents

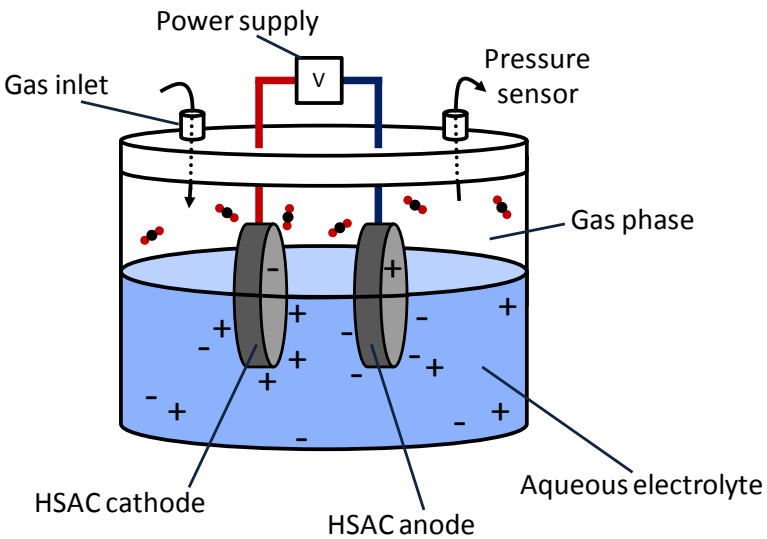
Entity Name	Description
Lehigh	Electric field swing adsorption
Texas A&M	Stimuli-responsive MOFs
MIT	Electrochemically Mediated Separation
LBL	**High-Throughput Discovery of Robust MOFs**
ORNL	New ionic liquid chemistries deployed in hollow fibers

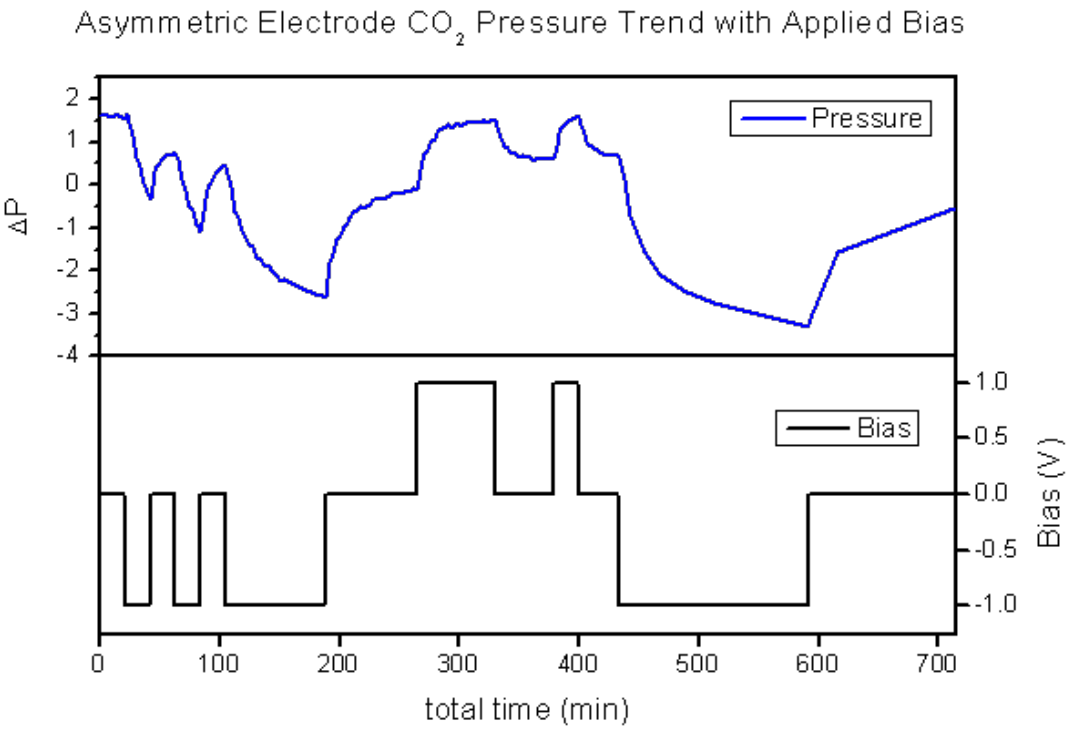


Supercapactive swing adsorption (SSA)

Team	Lehigh University			PI	Profs. David Moore & Kai Landskron
Federal funding	$566,641	Project start	01/01/10	Likely project end	06/30/12

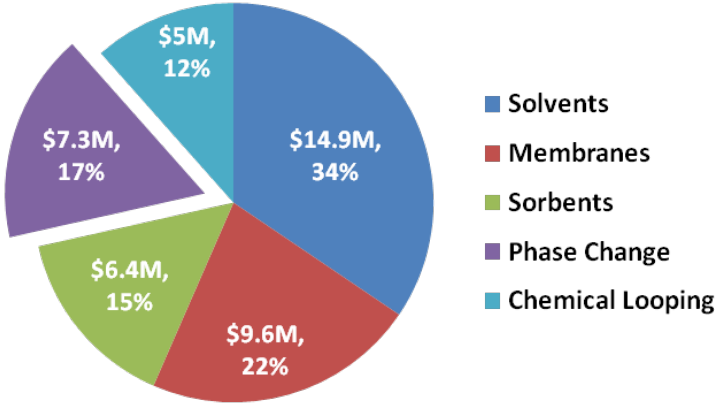
Electric field modulates adsorption/desorption in electrolytic capacitor-like setup





Phase Change

Entity Name	Description
GE	**Phase-Changing Absorbents**
Notre Dame	Ionic Liquids Involving Phase Change
ATK	Inertial CO_2 Extraction System
SES	Cryogenic Carbon Capture

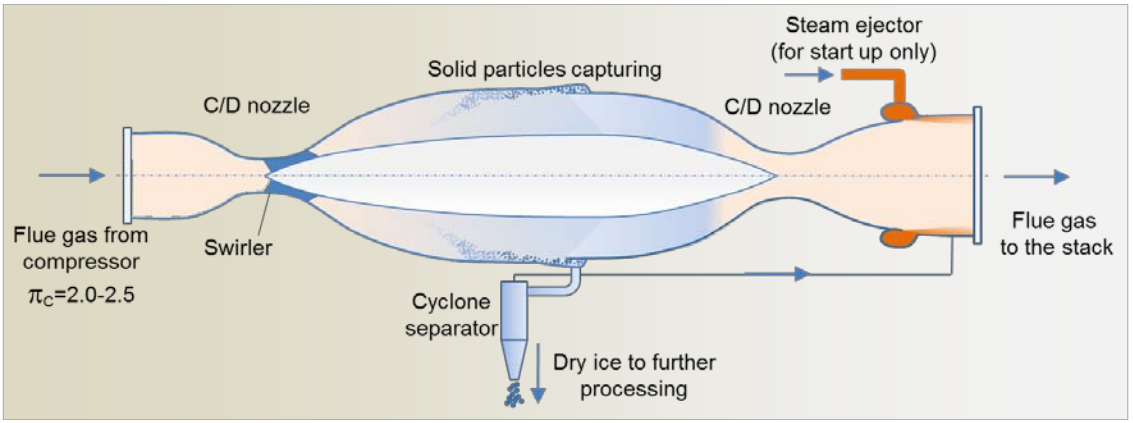


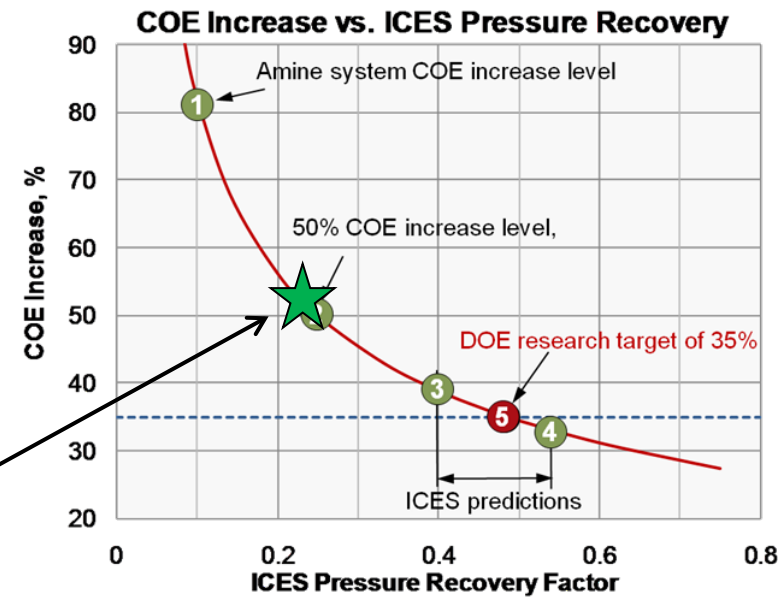
A high efficiency inertial CO_2 extraction system (ICES)

Team	**ATK,** ACENT Labs			PI	Dr. Vladimir Balepin
Federal funding	$2,692,868 (Phases 1&2)	**Project start**	07/15/10	**Likely project end**	05/15/11 (Phase 1), 06/30/13 (Phase 2)

Supersonic Expansion Drives Separation

Converging/diverging nozzle expands flue gas. Inertial forces separate solids.

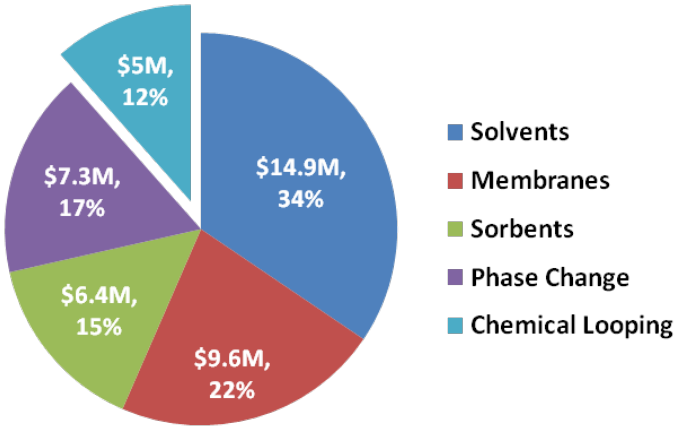




Pressure recovery currently estimated as ~ 25%; path forward identified for 40-50%

Chemical looping

Entity Name	Description
Ohio State	Pilot scale chemical looping at NCCC



IMPACCT Summary

- ARPA-E is funding a variety of early stage R&D projects with the intent of drastically reducing the cost of CCS
- Areas targeted for improvement
  - Parasitic energy requirements
  - Capital costs
  - Integration challenges at existing plants
- Preliminary projections of energy savings show a potential to reduce capture costs to the range of $20 to $50/ ton of CO_2 captured*
  - 5 Talks on Tuesday afternoon beginning at 3 pm
  - All 20 projects will have posters in the Tuesday evening poster session/reception

* More detailed modeling and successful R&D performance are still required for validation