Overview of ARPA-E in CCS

Karma Sawyer, Ph.D.
Assistant Program Director, ARPA-E

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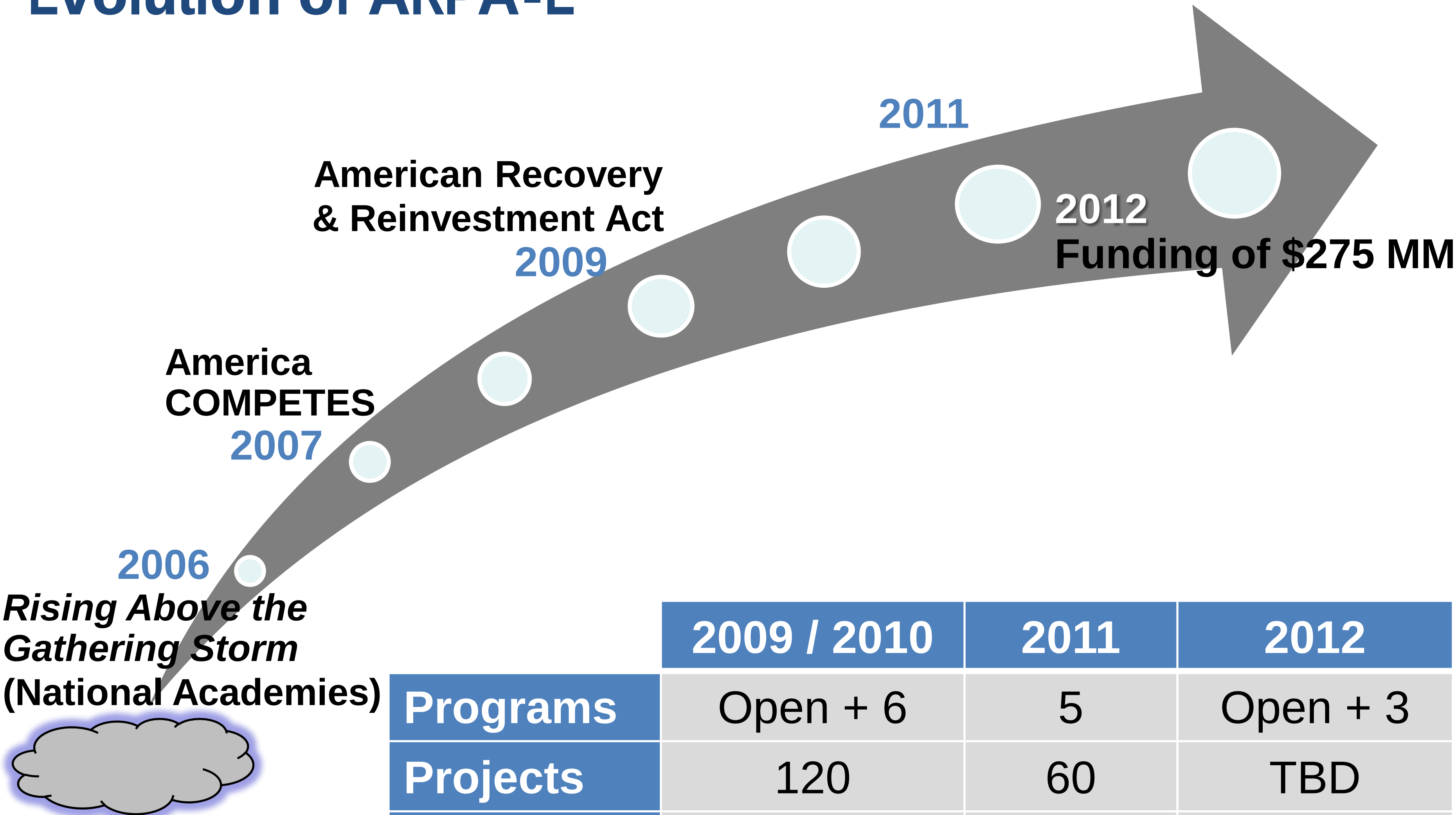
Evolution of ARPA-E



	2009 / 2010	2011	2012
Programs	Open + 6	5	Open + 3
Projects	120	60	TBD
Dollars (MM)	$366	$156	TBD

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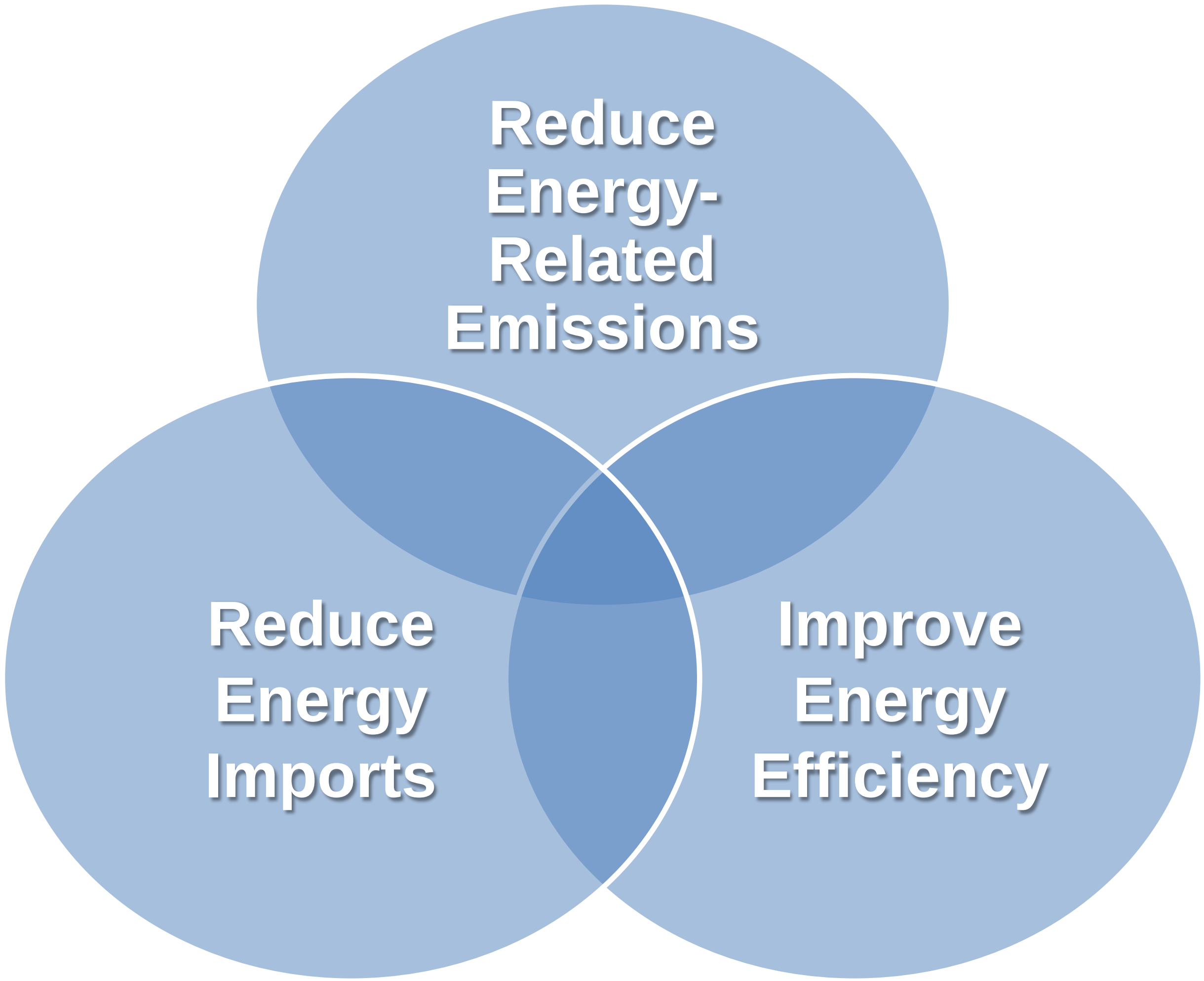
ARPA-E Mission

To enhance the economic and energy security of the U.S.

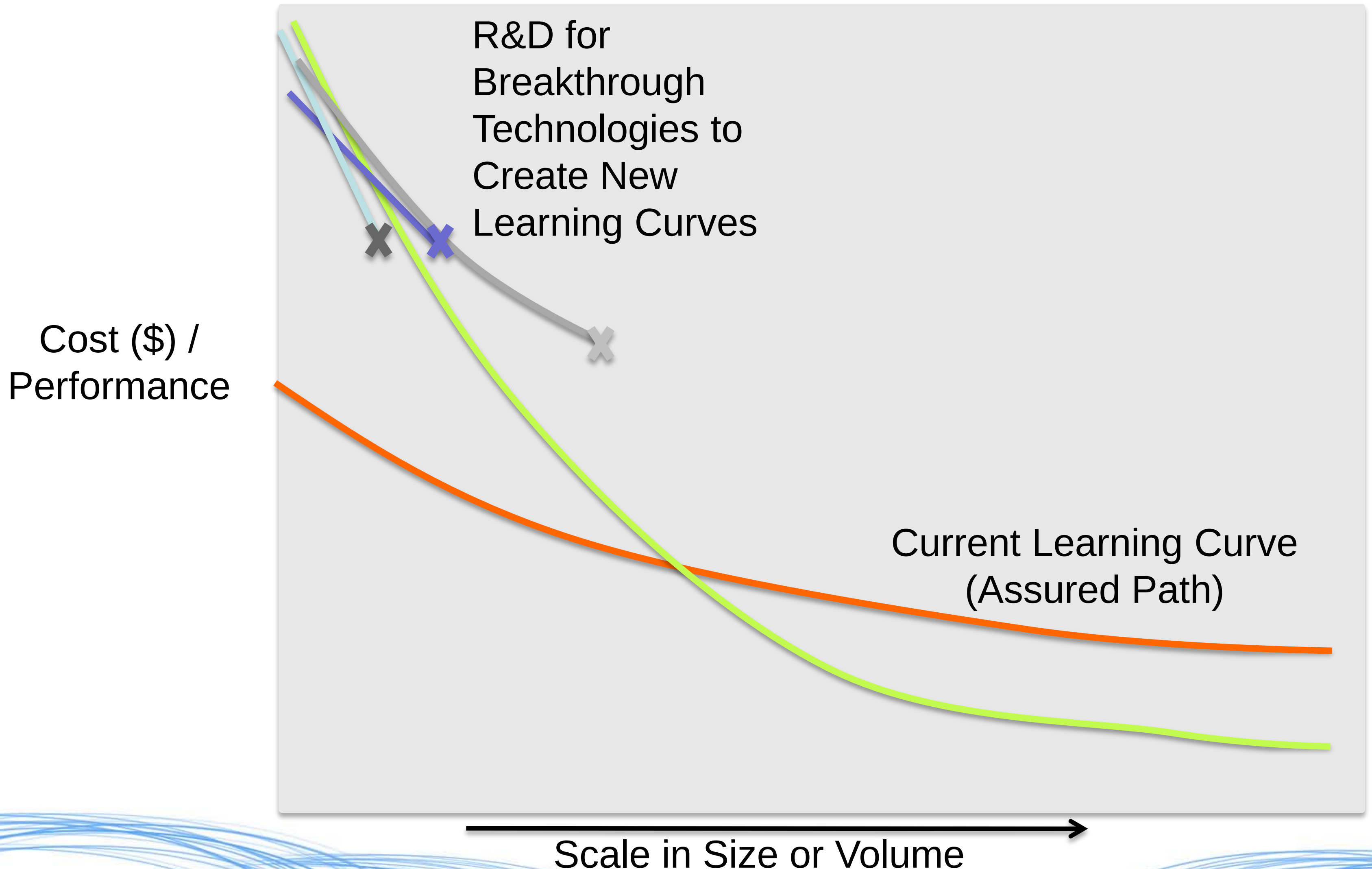
To ensure U.S. technological lead in developing and deploying advanced energy technologies

ARPA-E Mission



Advanced Transformative Technologies

Creating New Learning Curves



ARPA-E is currently running four FOAs - three focused and one broad

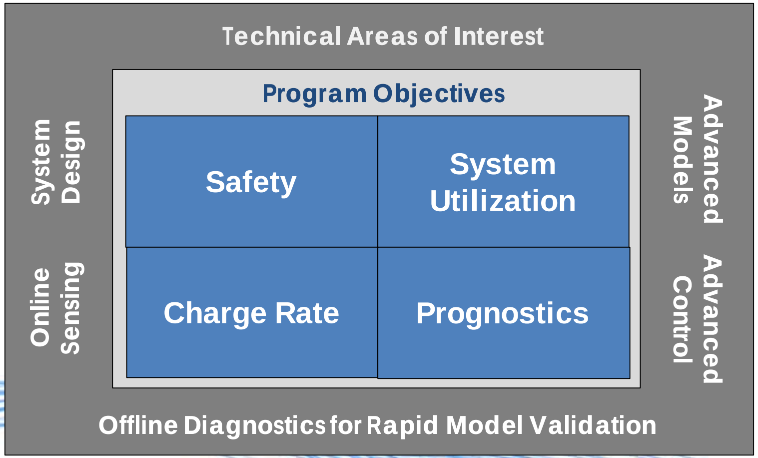
Methane Opportunities for Vehicular Energy (MOVE)

Vehicle Storage + Home Refueling
< $2000

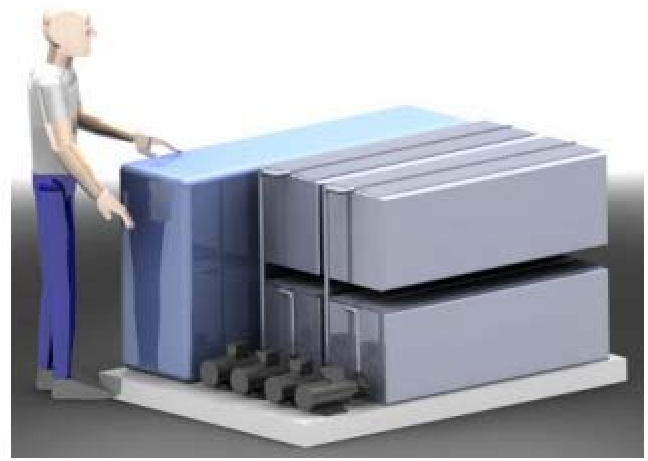
Open FOA

Biofuels
Solar
Fuel cells
Grid transmission
Grid scale storage
Wind
Conventional generation

Advanced Management and Protection of Energy-storage Devices (AMPED)



Energy Storage SBIR/STTR



MOVE Program

Methane Opportunities for Vehicular Energy

Objectives

- 5-yr payback for light duty natural gas vehicles
- Conformable tanks with energy density = CNG
- Convenient, low-cost at-home refueling

Vehicle Storage + Home Refueling

< $2000

Program director: Dane Boysen

Est. award date: Sep 2012

No. projects: 7-10

Investment: $30M

Approach 1: Low pressure storage (< 500 psi)

- Sorbent materials with energy density = CNG

Approach 2: High pressure storage (3,600 psi)

- High strength, conformable tanks + low cost compression

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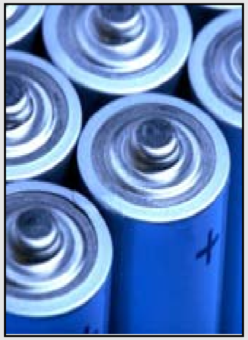
12 Focused Programs

Transportation

Electrofuels

BEEST



PETRO

MOVE

End-Use Efficiency

HEATS

BEETIT

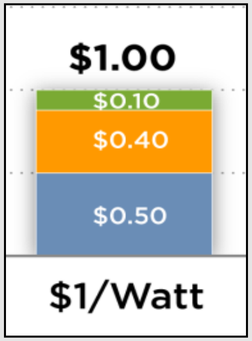
Stationary Power

IMPACCT

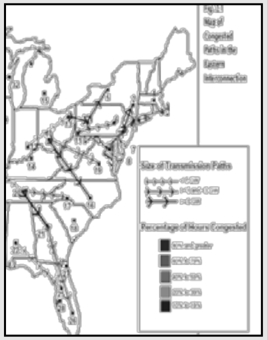
ADEPT

GRIDS

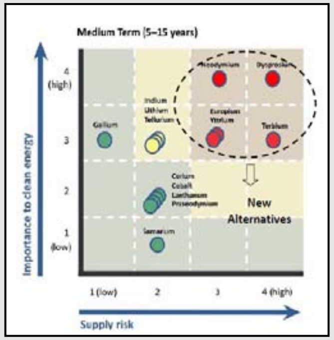
Solar ADEPT



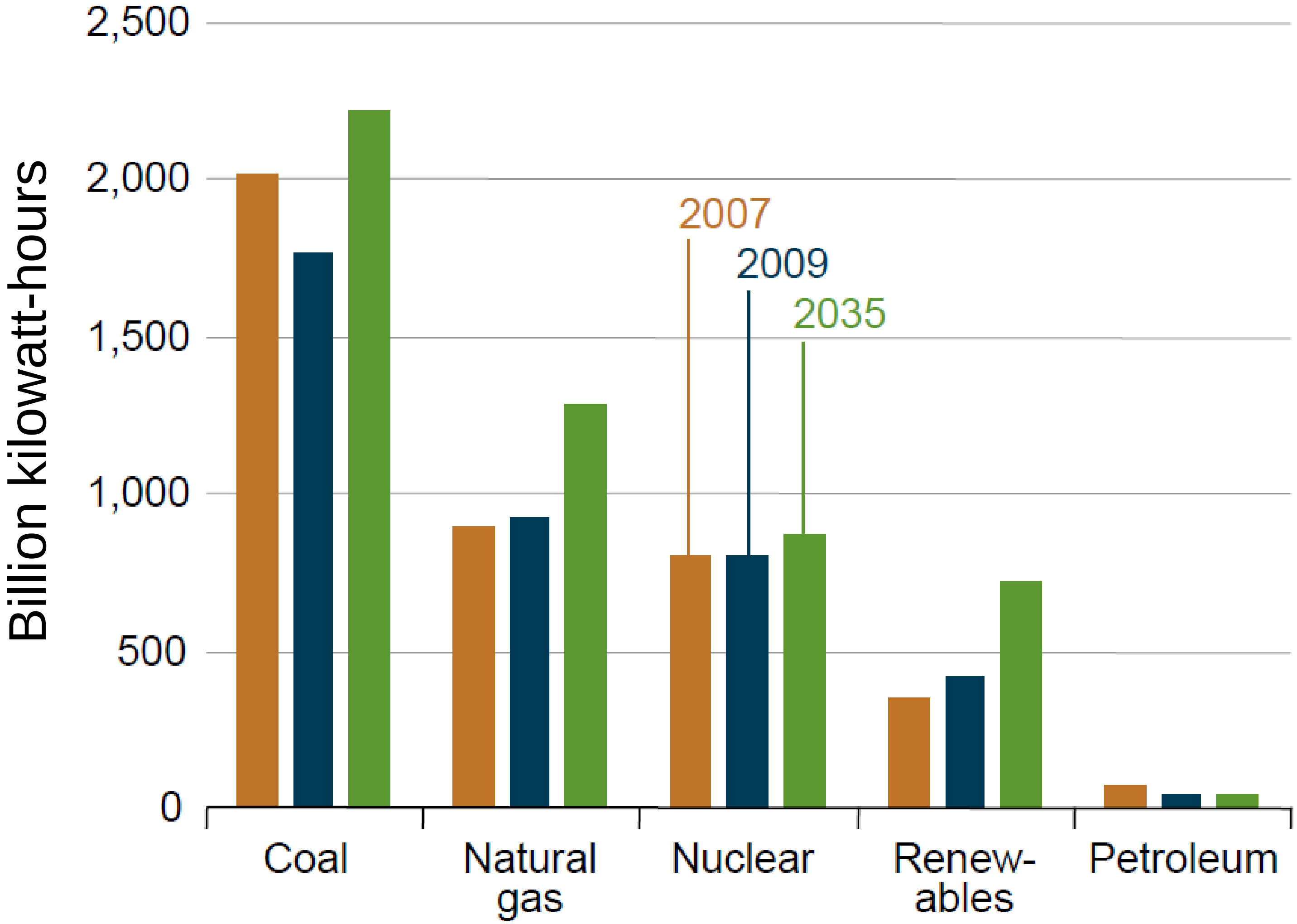
GENI



REACT



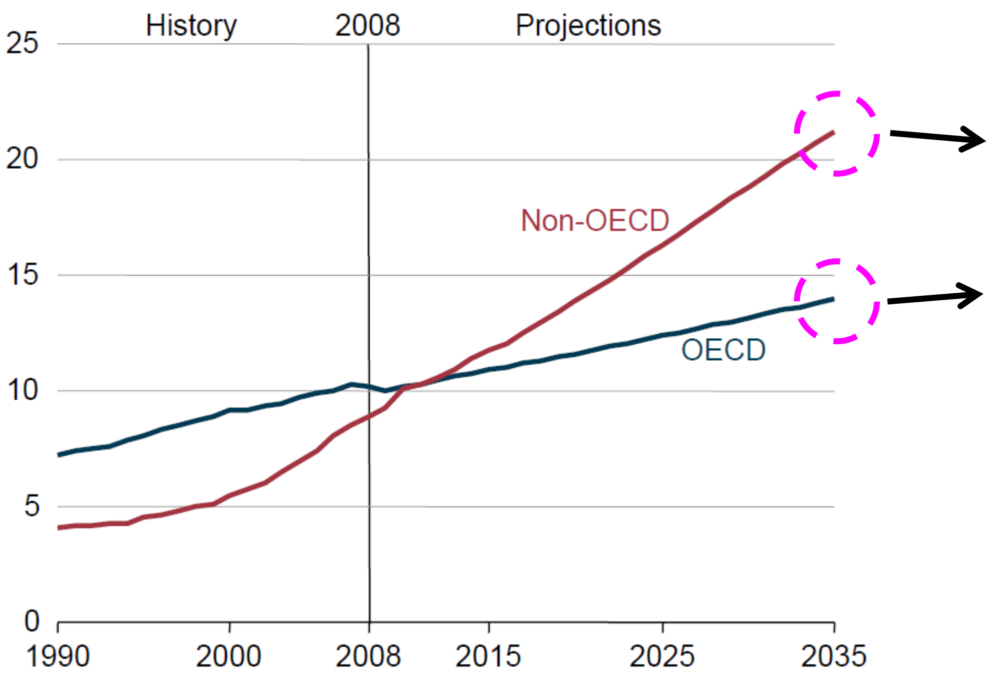
U.S. electricity generation projections

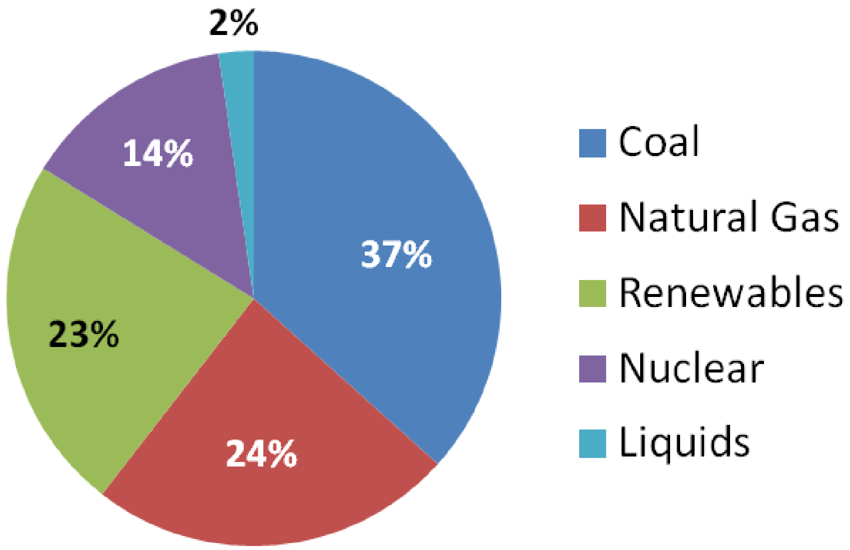


Source: EIA Annual Energy Outlook (2011)

Worldwide electricity projections

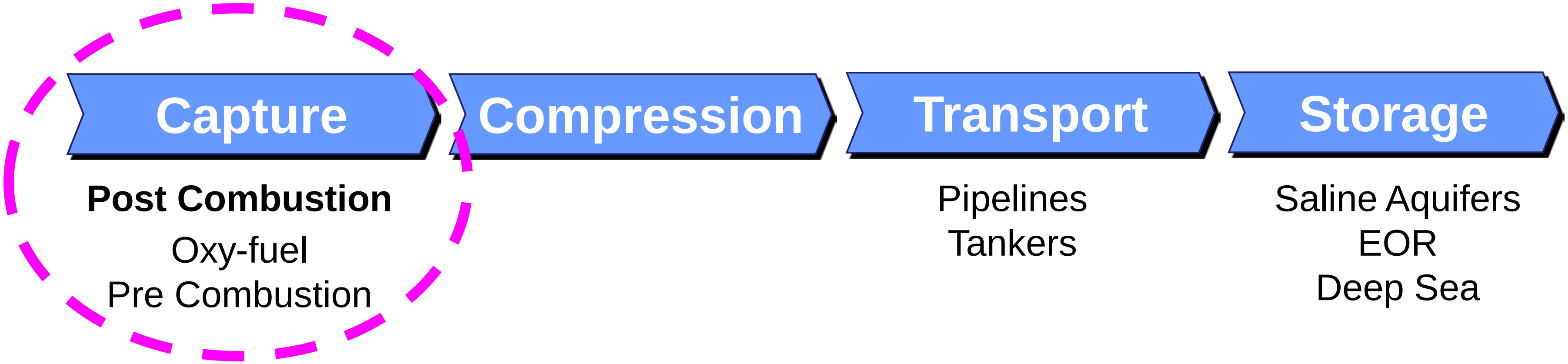
World electricity generation (trillion kilowatt-hours)



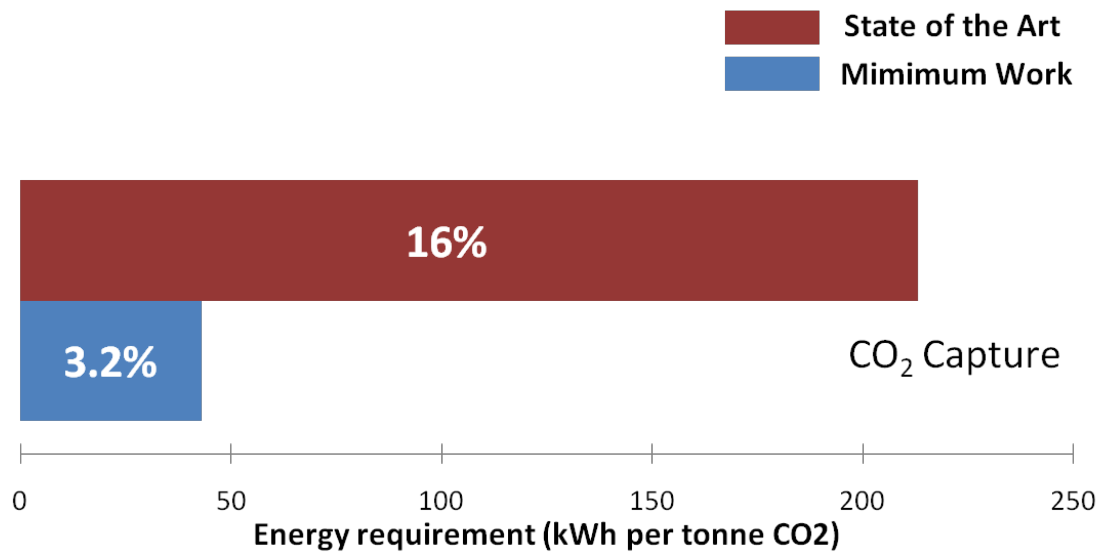


Source: EIA International Energy Outlook (2011)

Capture is the largest cost



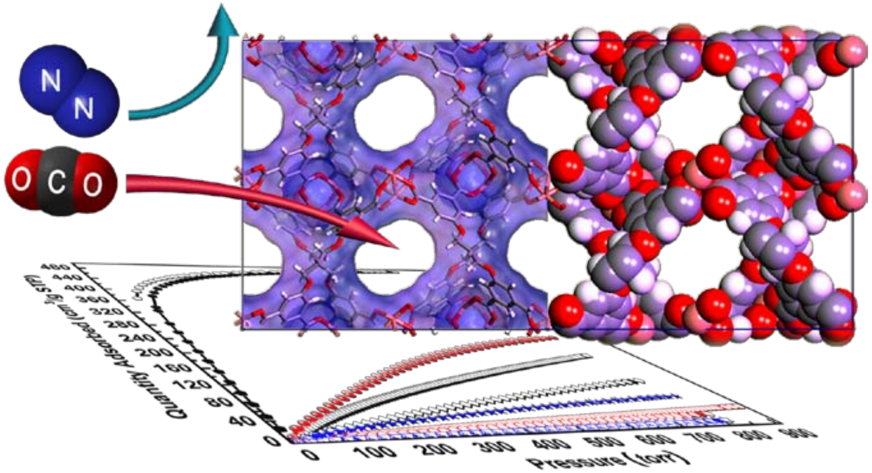
Energy comparison, with parasitic load %



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

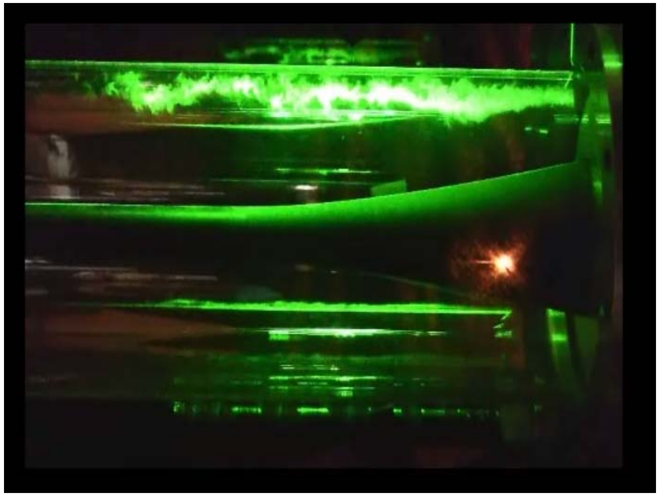
Two Approaches to Reduce Capture Costs

Advanced Materials



Texas A&M

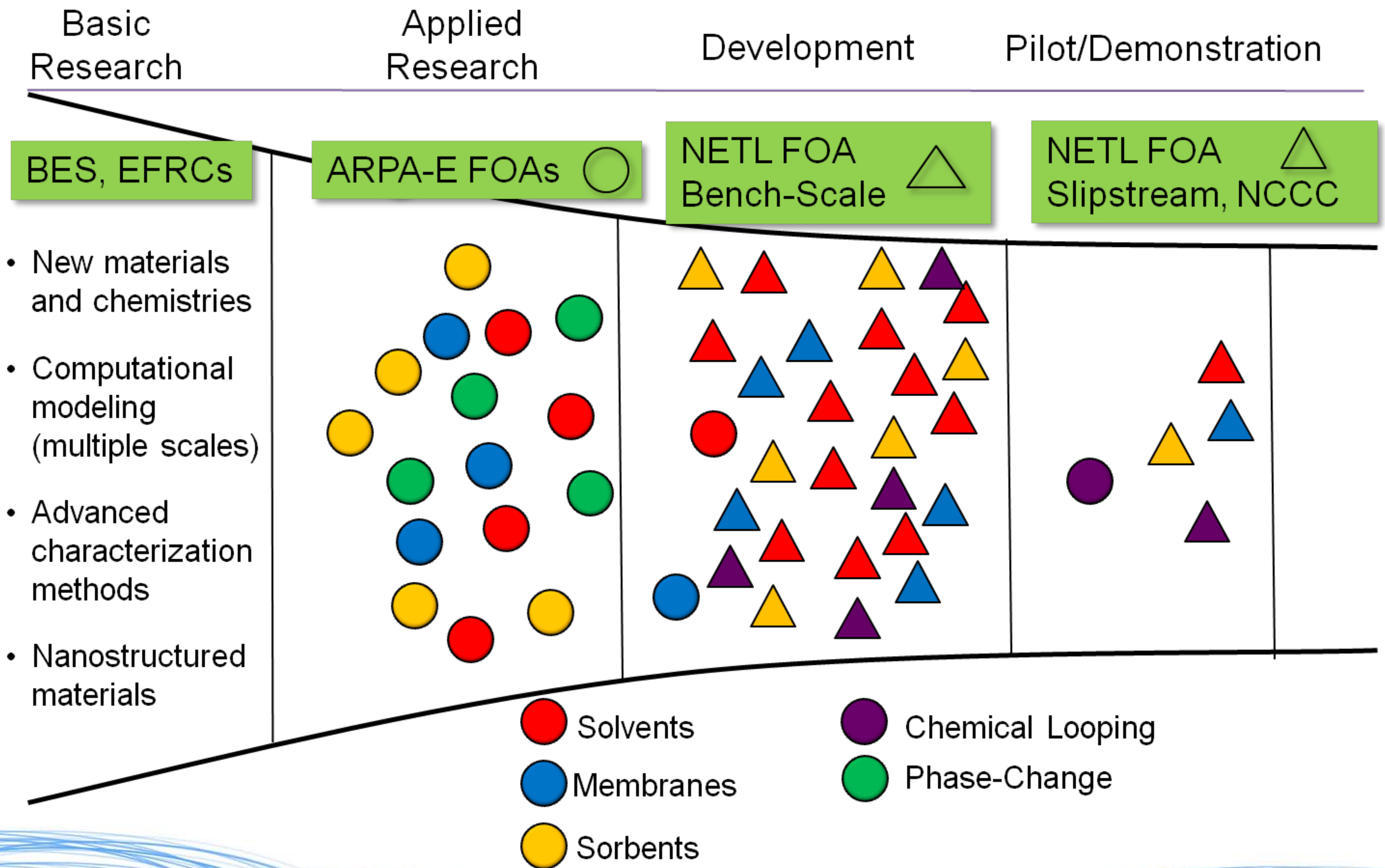
Innovative Processes



ATK

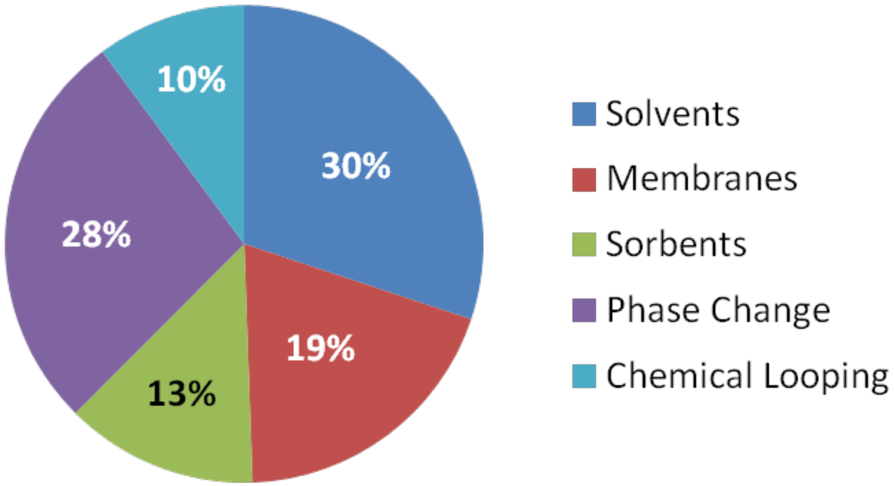
High risk, high reward projects that can disruptively lower the energy needs & cost structure for capture

Where ARPA-E Fits in with CCS

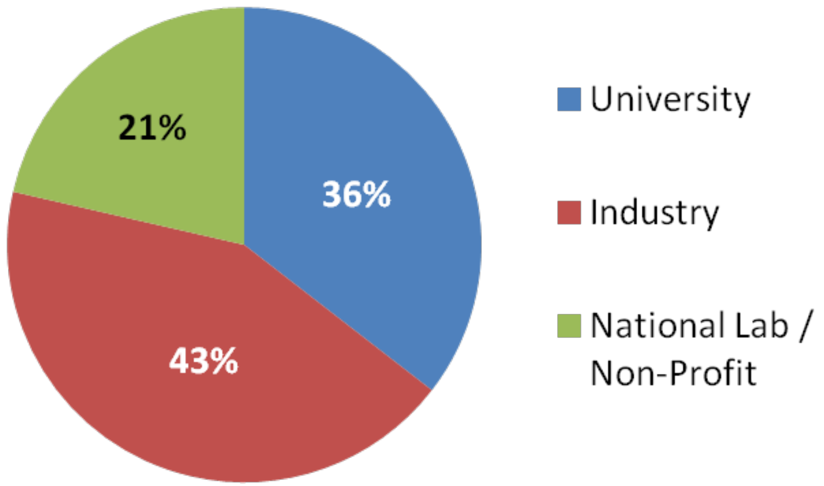


Carbon capture projects from FOA-1 and IMPACCT: $49.4M in funding

Funding by category

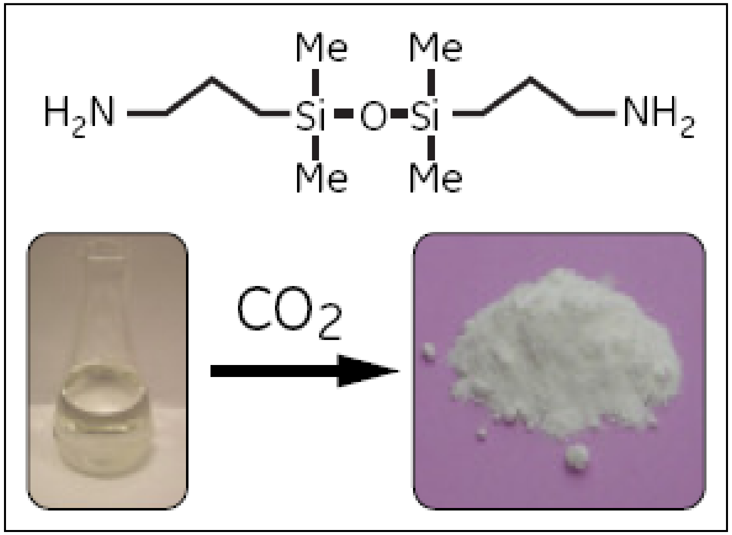


Funding by entity type

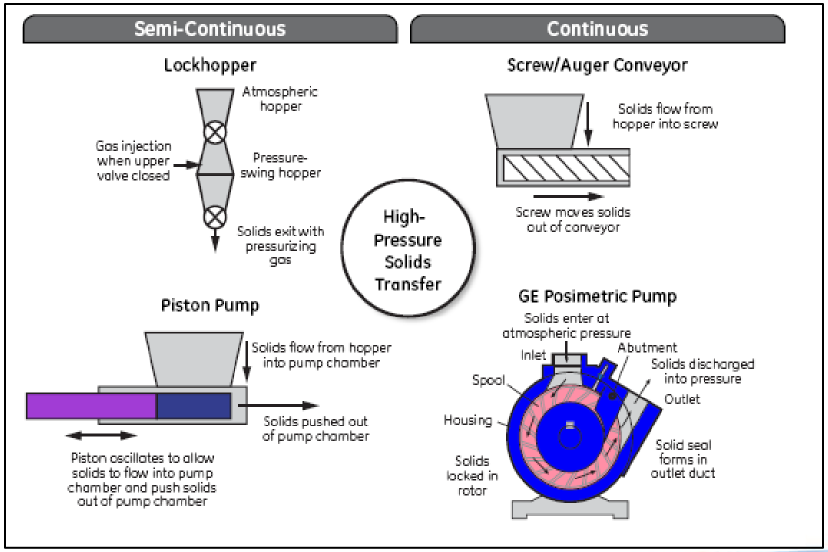


CO_2 capture process using phase-changing absorbents

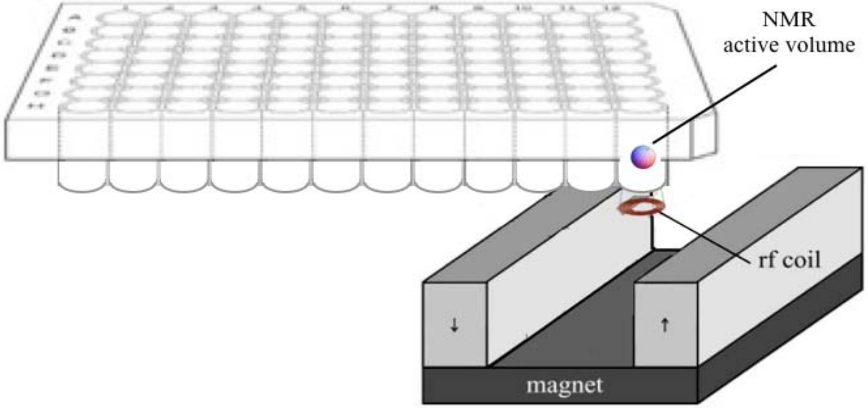
Phase-changing materials; *allow exploration of unconventional tradeoffs between OPEX and CAPEX. Preliminary economic assessments are promising.*



Solids handling; *team has overcome early limitations and has a unique desorption process.*

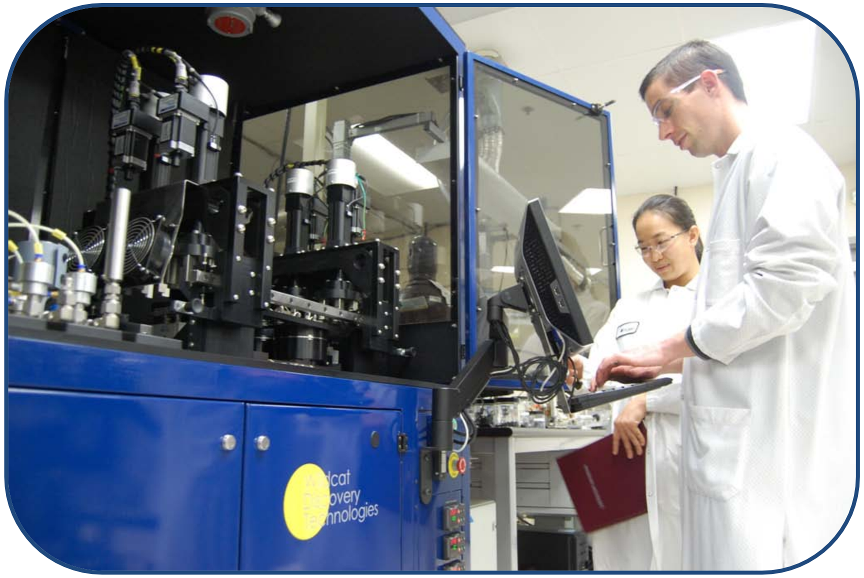


High-Throughput (HT) Metal-Organic Framework (MOF) Discovery



HT surface area measurements

- Correlate NMR relaxation times to surface area – faster than BET
- Robotic instrumentation used with single-sided NMR



HT sorption isotherms

- Before: **8 weeks** to measure 28 MOFs
- Now: only **1 day** to measure the same number
- Next step: Gen 2 system that measures 28 samples at a time with mixed gases

BERKELEY LAB
Wildcat Discovery Technologies
EPRI ELECTRIC POWER RESEARCH INSTITUTE

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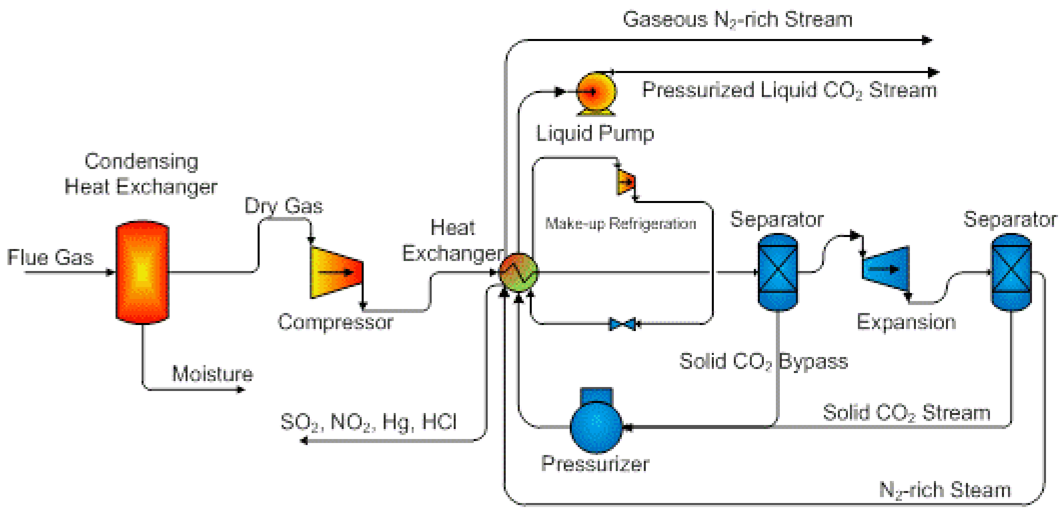
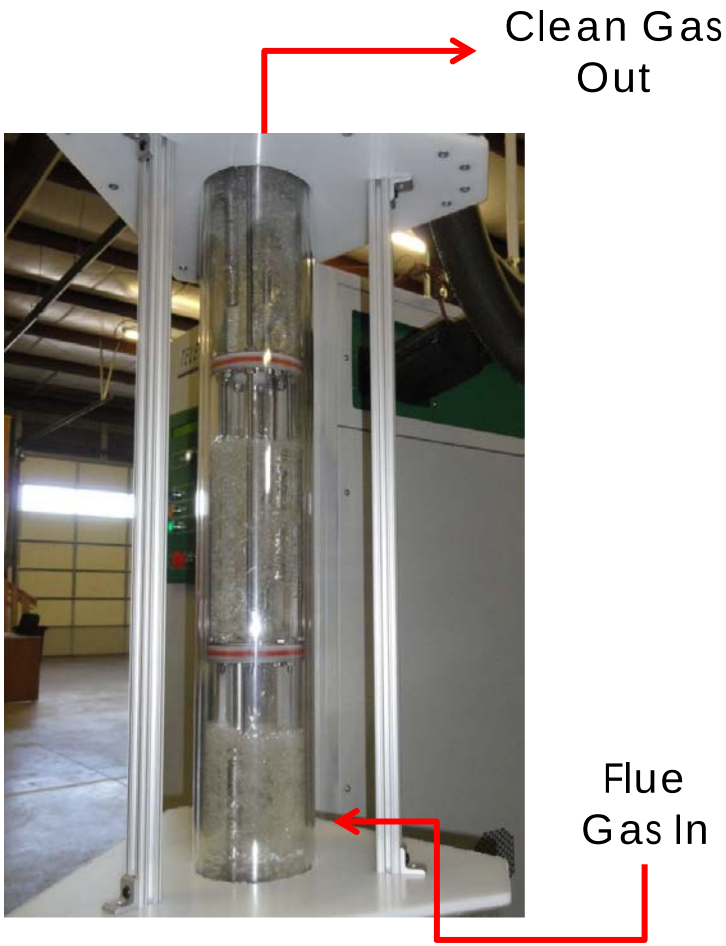
Cryogenic Carbon Capture

De-sublimation; *CO_2 from flue gas is removed by a classical separation process. The SES team offers a creative approach with a unique value addition for energy storage.*

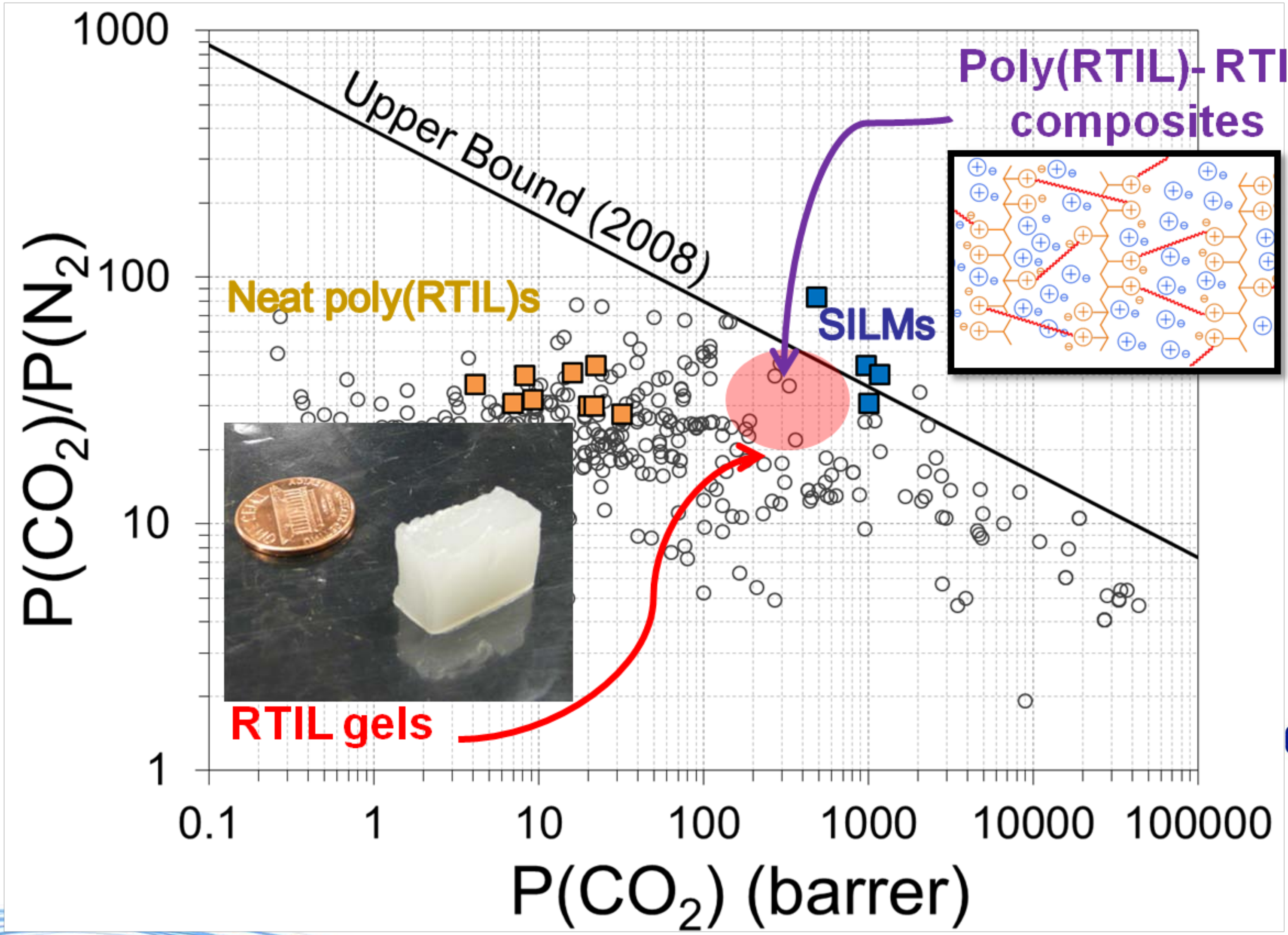




Multi-stage contactor; *flue gas is fractionated in a high surface-area staged configuration.*

Final target
- integrated unit operations
- campaigns on real flue gas

A 10,000 GPU Selective Membrane for CO_2



Colorado
University of Colorado at Boulder

Los Alamos
NATIONAL LABORATORY
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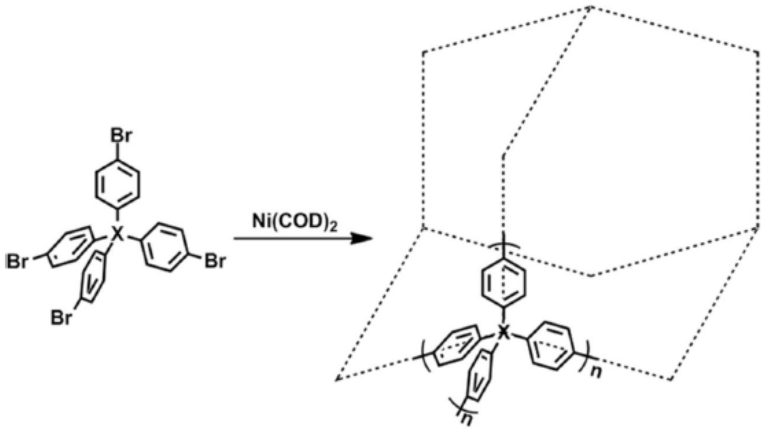
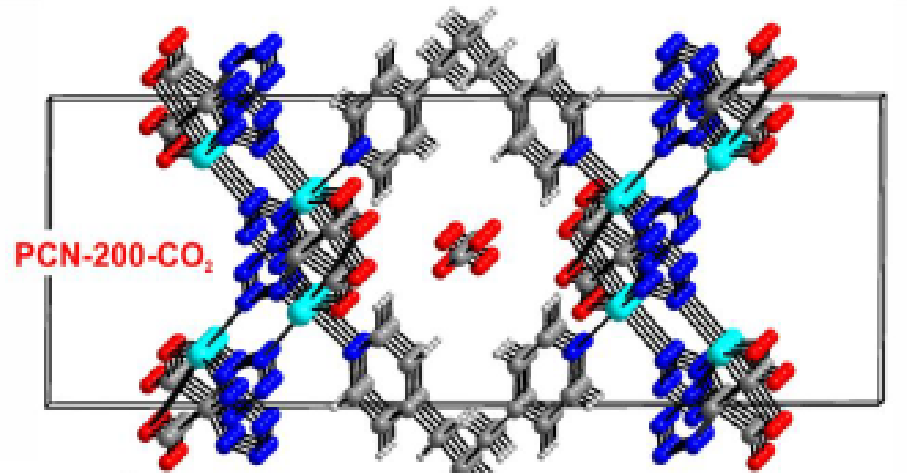
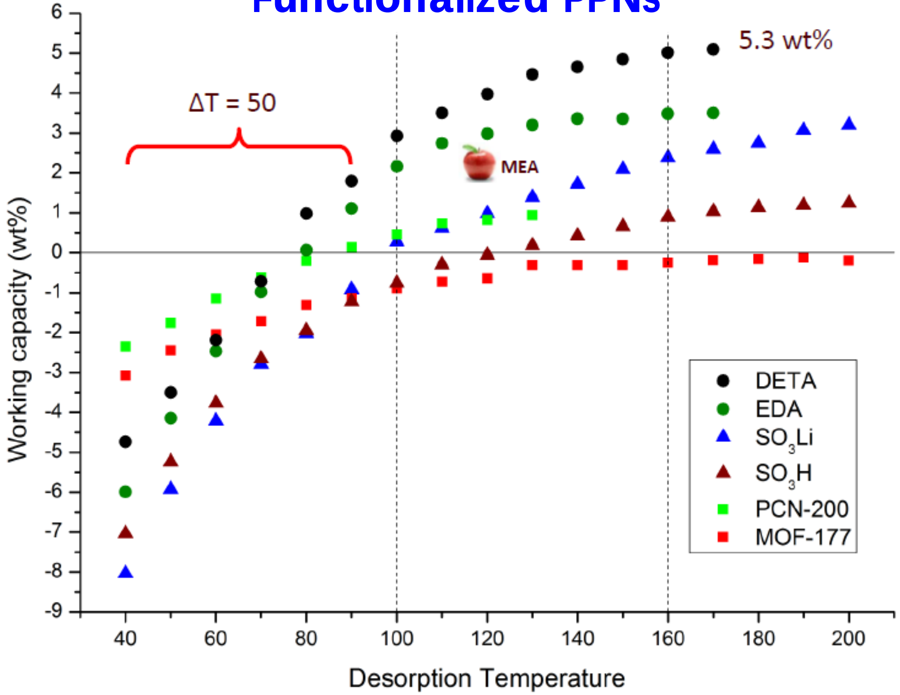
Robust Metal-Organic Frameworks (MOFs) and Porous Polymer Networks (PPNs)





Functionalized PPNs



PCN-200

- Chemically, thermally robust
- Selectivity > 200
- Simple, inexpensive synthesis

IMPACCT Summary

- $49.4 M Federal Funding (all ARRA funding)
  - 17 projects in post-combustion capture ($44.4 M)
  - 1 project in chemical looping demonstration at NCCC ($5 M)

- 2-3 years of funding per project, average $2.2M
  - Start at TRL 2-3 (lab scale)
  - Finish at TRL 4-6 and transition to NETL or commercial groups
  - Most projects finish between fall 2012 and fall 2013

Related Oral Presentations

Wednesday afternoon

- **Codexis** – Directed evolution of carbonic anhydrase catalysts
- **LLNL** – Catalytic Improvements of Solvent Capture Systems
- **ATK / ACENT Labs** – Supersonic duct for solid CO_2 separation
- **RTI** – Non-aqueous solvents
- **ORNL / Georgia Tech** – Hollow-fiber ionic liquid sponges