Reactive Carbon Capture Project Review Meeting - Summary and Key Findings

Sara Hamilton (Fellow)

2024 FECM / NETL Carbon Management Research Project Review Meeting

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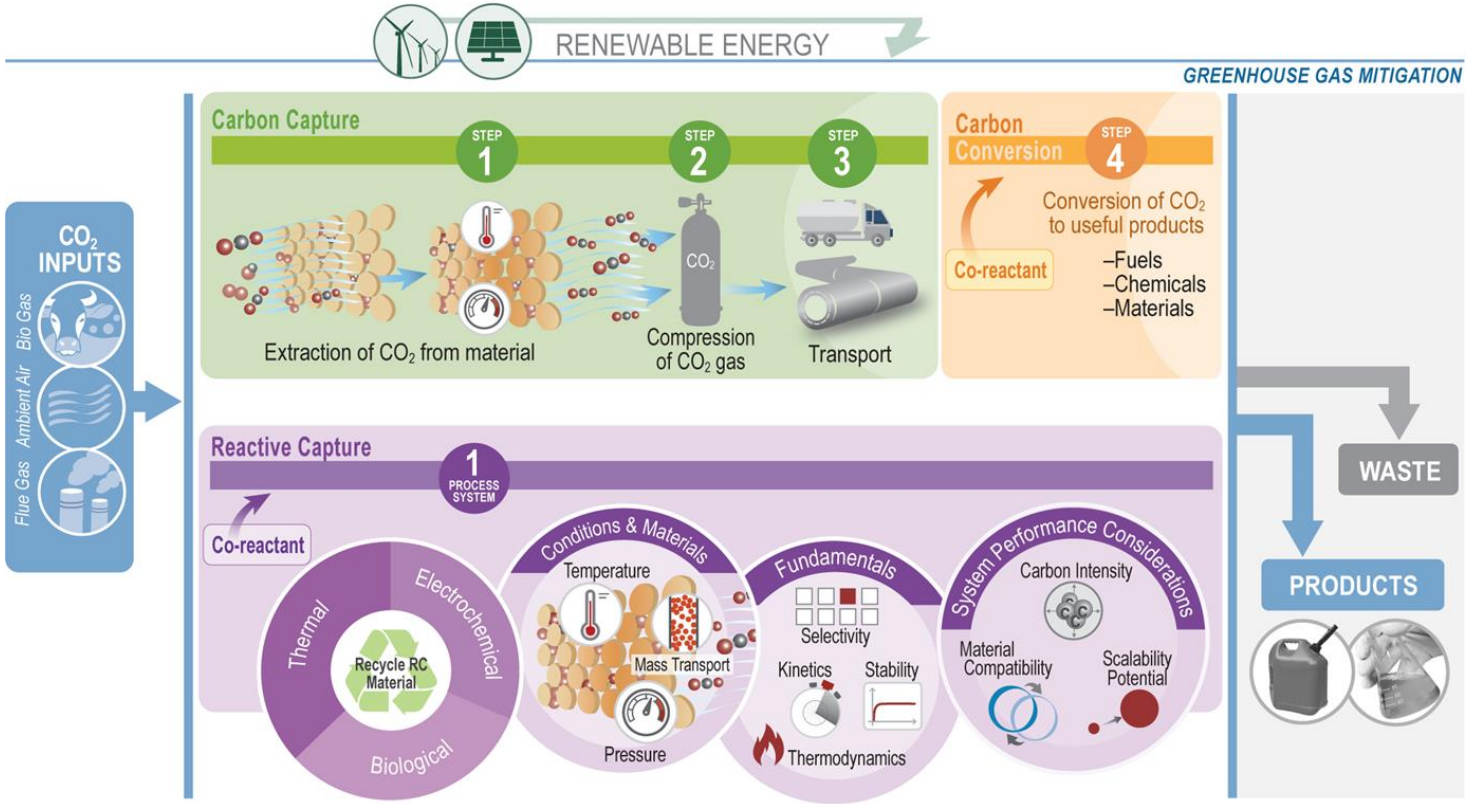
U.S. DEPARTMENT OF ENERGY

Fossil Energy and Carbon Management

Motivation: Reactive Carbon Capture (RCC)

Process of capturing CO_2 from a mixed gas stream and converting it into a valuable product *without going through a purified CO_2 intermediate*



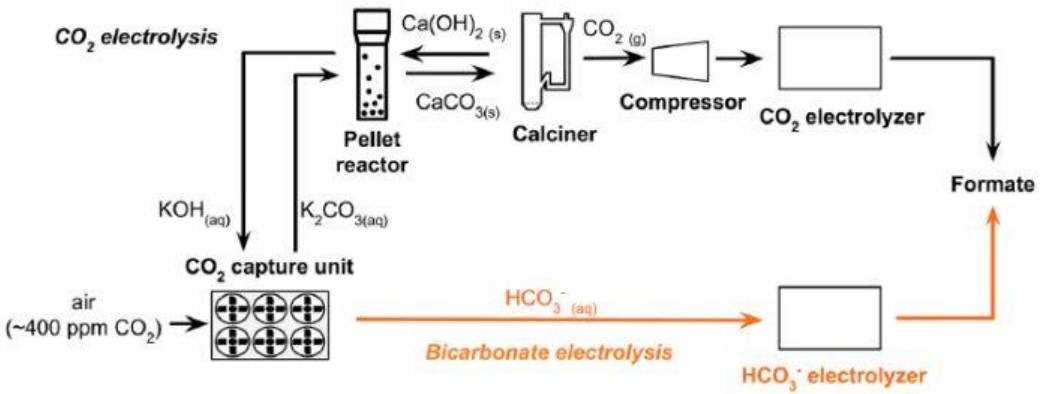
Freyman et al. *Reactive CO_2 capture: A path forward for process integration in carbon management*. Joule (2023).

Motivation: Reactive Carbon Capture (RCC)

1. Process intensification
2. Increased energy efficiency
3. Reduced capital expenses
4. Potential to eliminate transport and storage step
5. Integration with variable CO_2 sources (DAC, PSC Power and PSC Industrial)

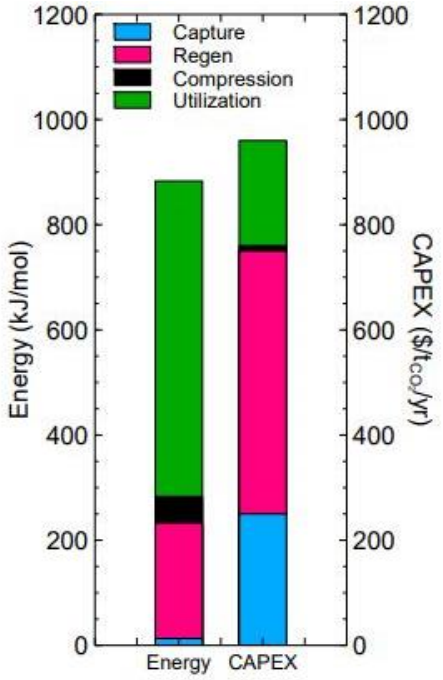
RCC Process Intensification: DAC CO_2 Regeneration

Sequential CO_2 Capture + Conversion



Reactive Capture (Electrochemical)

Sequential CO_2 Capture + Conversion

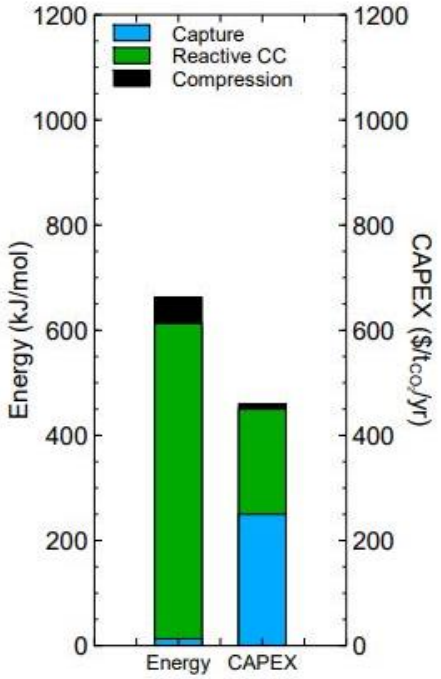


20-30% Decrease in Energy Use

50% Decrease in CAPEX

In DAC the energy and capital intensity is in the regeneration step

Reactive Capture

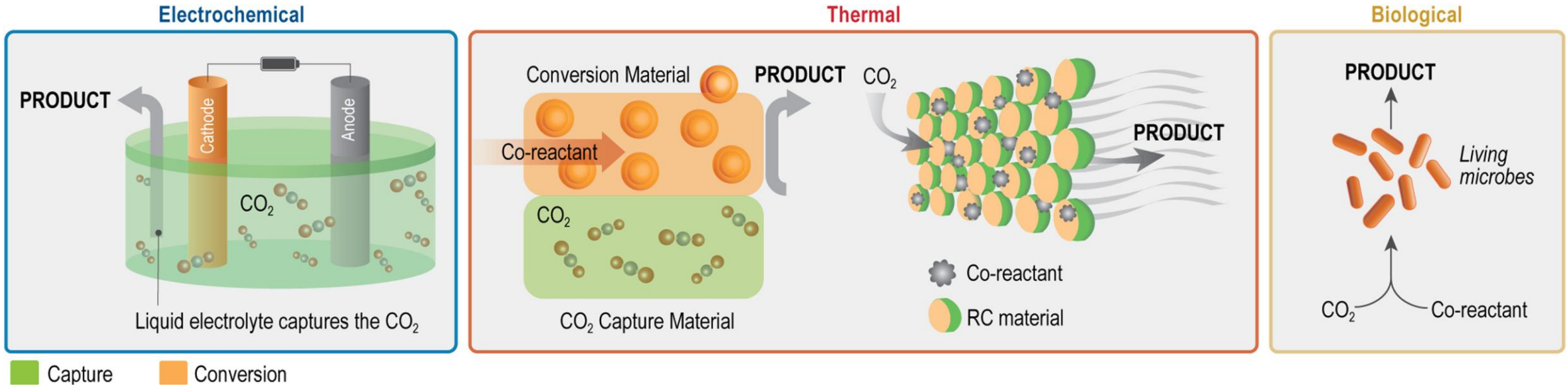


20-30% reduction in energy intensity and 50% reduction capex relative to sequential route

Ian Robinson, *ARPA-E 2022 workshop presentation*. 2022 Workshop | arpa-e.energy.gov.

Reactive Carbon Capture (RCC) Approaches

Multiple technology approaches to RCC, most are at the proof-of-concept stage



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FECM Reactive Capture Portfolio: National Labs

	CO_2 Source	Capture Media	Conversion Process	Product
Lawrence Livermore National Laboratory	Air 	Sorbents	Catalytic	RNG
NREL Transforming ENERGY	Point Sources 	Sorbents	Catalytic	MeOH
Oak Ridge National Laboratory		Solvent (amino acids)	Electrochemical	EtOH
Oak Ridge National Laboratory		Dual functional porous catalytic polymer	Catalytic	Formic Acid
Pacific Northwest National Laboratory		Water Lean Solvent	Lignin Fixation	Composite building materials
Pacific Northwest National Laboratory		Water Lean Solvent	Catalytic	Methanol, methyl formate, ethylene glycol,

FECM Reactive Capture Portfolio: SBIRs Examples

Point Sources

Methanol

TDA RESEARCH

Sorbent & e-chem

CNT

SkyNano

Li_2O & e-chem

DMC

MPT

Membrane
& catalyst

Concrete

C-Crete TECHNOLOGIES

Mineralization

Construction Materials

CTS CARBON TO STONE

Mineralization

Fertilizer

Fossil Energy Research

+ ammonia

Air

Methanol

ADEM ADVANCED ENERGY MATERIALS

Nano-wire plasma
catalytic capture

Ethanol

MoleculeWorks
Efficiency for a Sustainable World

Sorbent & e-chem

Concrete

C-Crete TECHNOLOGIES

Mineralization

Natural Gas

Susteon

Sorbent
& catalyst

FECM Reactive Carbon Capture (RCC) Portfolio

- Majority of the projects at TRL 3-4 (lab/bench materials & component R&D)

- Broad distribution = f (products, CO_2 conversion, carbon capture material, CO_2 source)

Challenges:

Technical:

- Kinetics mis-match for CO_2 capture process (fast) and CO_2 conversion
- Process incompatibility: capture (O_2, lower T) vs. conversion (reducing atmosphere, higher T)
- Low capture efficiency for mineralization/fixation approaches
- Durability of capture and conversion media with impurities: oxygen, water, SO_x, NO_x

Techno-economic:

- Reactive capture vs. [capture + conversion]
- CO_2 product market size

RCC Project Review Meeting (January 2024)

Key Objectives

1. Review of **RCC activities within DOE** (FECM, ARPA-E, IEDO, Office of Science-BES)
2. Understand **current challenges and RD&D needs** the field of RCC
3. Identify **activities needed to scale-up RCC to achieve continuous operation**
4. Identify **enabling technologies** to overcome current challenges of RCC
5. Identify **promising approaches and products** to target using RCC

Participants

Current DOE Projects

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Researchers

Cornell University (Founded A.D. 1865) | NETL National Energy Technology Laboratory | USC | UBC

Industry

Carbon Engineering | twelve | CarbonBuilt

+ Participants from academia, industry, government

Findings to inform next funding opportunity announcement

Key Take-Aways: Research Questions

- *What are the biggest technology challenges in advancing RCC technology towards process integration?*
- *What are unanswered scientific questions in RCC?*

RD&D Needs

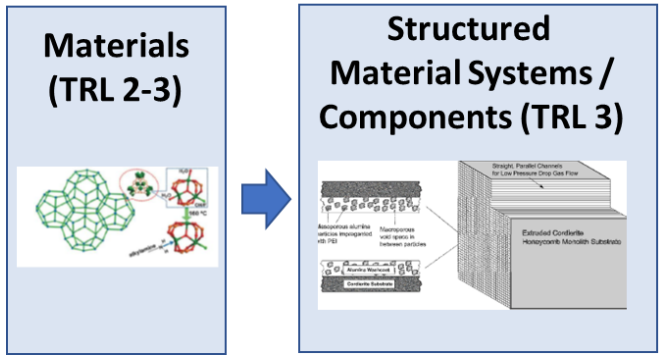
1. **Integrated RCC systems** tested in real environments at small scale

2. **Analysis efforts (TEA + LCA) to demonstrate RCC value proposition** and set standard metrics and goals

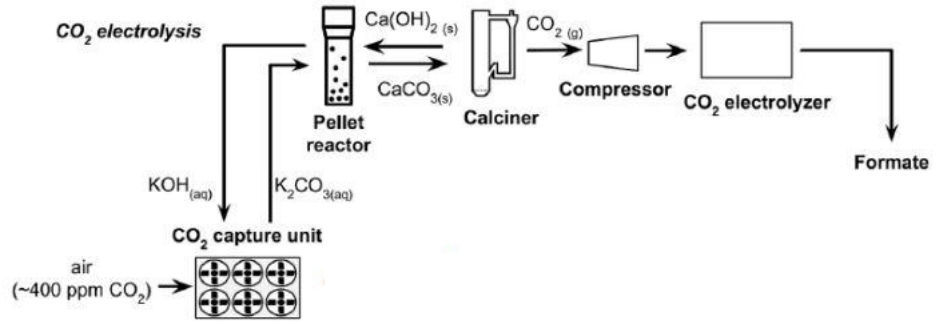
3. Develop **modular and dynamic RCC systems** that can deal with intermittency

4. **Re-evaluate existing carbon management technology with RCC**. Can processes be redesigned?

5. **Co-optimization of materials + processes for RCC**: new CO_2 reactivities, materials, catalysts…



Sequential Capture + Conversion



Reactive Capture

Key Take-Aways: RCC Market Pull and Collaboration

Market Pull Scenarios

- *What are promising products to make via RCC?*
- *What is the main value proposition for RCC?*

Recommendations/Next Steps

1. Conduct technology-agnostic **analysis of market size** and potential impact of RCC products in different sectors and industries

2. Promote **collaborations between technology developers and off-takers** of possible RCC products

3. Develop **policy incentives** for RCC technologies including spectrum of CO_2 conversion products

Fostering Collaboration

What can DOE do to most effectively advance and foster collaboration in the field of RCC?

Recommendations/Next Steps

1. Align **RCC efforts across DOE offices** to provide multi-office funding and address TRL gaps

2. Establish **multi-lab consortium** (academia, national labs, industry) that fosters partnerships

3. **DOE funding support to advance TRL** of existing RCC technologies

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U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Relevant NOI: FOA Carbon Management 2614

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Notice of Intent No.: DE-FOA-0003397

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This is a Notice of Intent to Issue
Funding Opportunity Announcement No. DE-FOA-0002614
Title: Carbon Management (Round 6)

The Department of Energy (DOE) National Energy Technology Laboratory (NETL) intends to issue Funding Opportunity Announcement (FOA) No.: DE-FOA-0002614 on behalf of the Office of Fossil Energy and Carbon Management (FECM) in the middle of 2024 calendar year.

AOI-1F. Reactive Carbon Capture Approaches for Point Source Capture or Atmospheric Capture with Integrated Conversion to Useful Products

Notice of Intent to issue Funding Opportunity Announcement DE-FOA-0002614 titled "Carbon Management (Round 6)" | netl.doe.gov

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Questions?