2023 FECM /NETL Carbon Management Research Project Review Meeting

Point Source Carbon Capture Breakout Session

August 28, 2023

August 2023

Point Source Carbon Capture

Dan Hancu

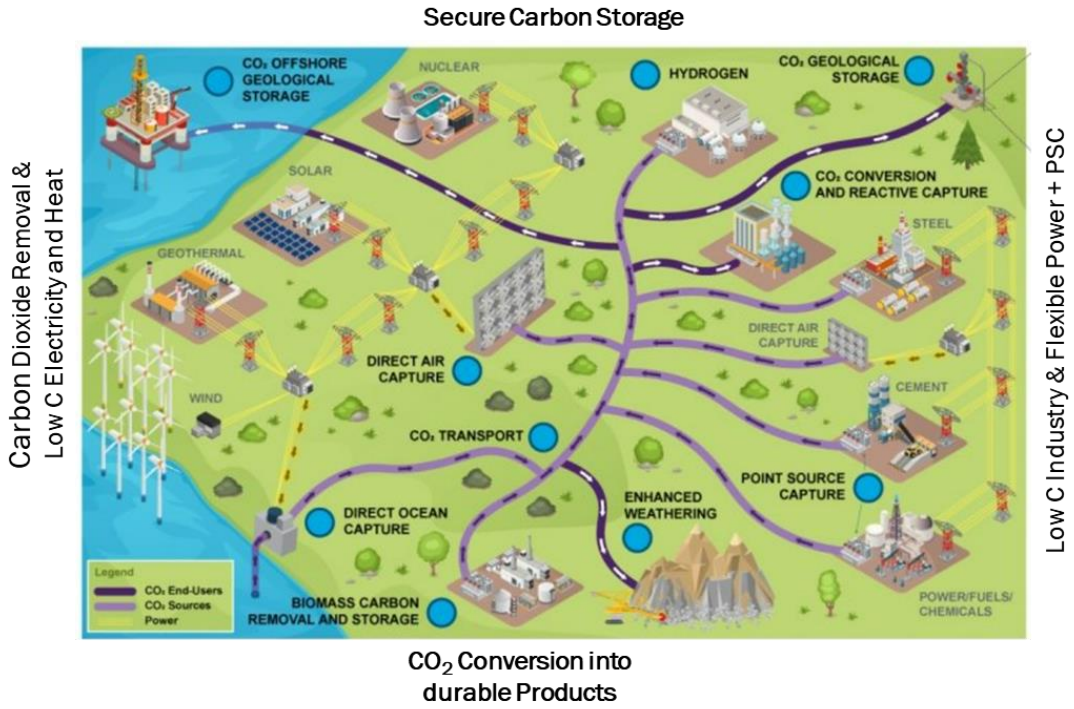
DIVISION DIRECTOR, POINT SOURCE CARBON CAPTURE
OFFICE OF FOSSIL ENERGY AND CARBON MANAGEMENT

dan.hancu@hq.doe.gov

U.S. DEPARTMENT OF ENERGY
Fossil Energy and Carbon Management

PSC Strategic Vision

Support demonstration of first-of-a-kind carbon capture on power and industrial sectors coupled with secure carbon storage, that will lead to commercially viable solutions for widescale deployment and facilitate a carbon-free economy by 2050, emphasizing robust analysis of life cycle impacts, and understanding air/water quality impacts.



Focus Area 1: Support Power Retrofit Demos

- Enabling technologies

Focus Area 2: Net Zero, Flex Power

- Technology development to support flexible CCS with high capture efficiency
- FEEDs to seed the formation of Carbon Hubs.

Focus Area 3: Support Industrial Retrofit Demos

- Enabling technologies

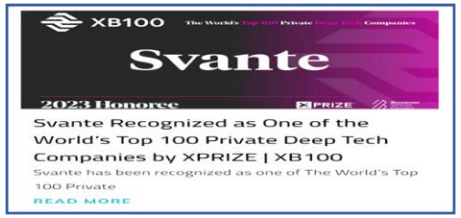
Focus Area 4: Integrated decarbonized industrial + CCS

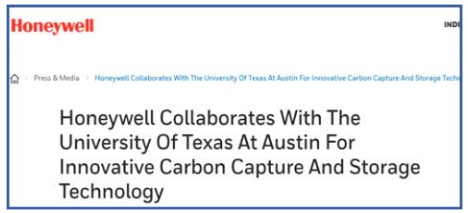
- Technology development for integrated decarbonized industrial processes coupled with transformational CCS
- FEEDs to seed the formation of Carbon Hubs.

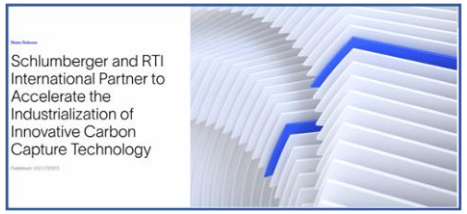
PSC Power Portfolio

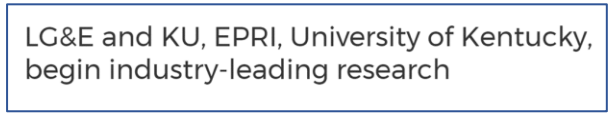
	Bench	Small Pilots	Large Pilots	CCS Demo
	 Testing novel materials & processes with simulated exhaust	 Bench- and Pilot-scale technology testing with real flue gas	 Engineering scale for integrated capture system	 Unit Wide
			No Carbon storage	+ Carbon transport & storage
ARPA-E	✓ FLECCS	✓ FLECCS		
FECM	✓	✓	✓ MTR, UIC, TCM	
OCED				✓ 25+ MW BIL Funded ✓

Commercial, licensing deals

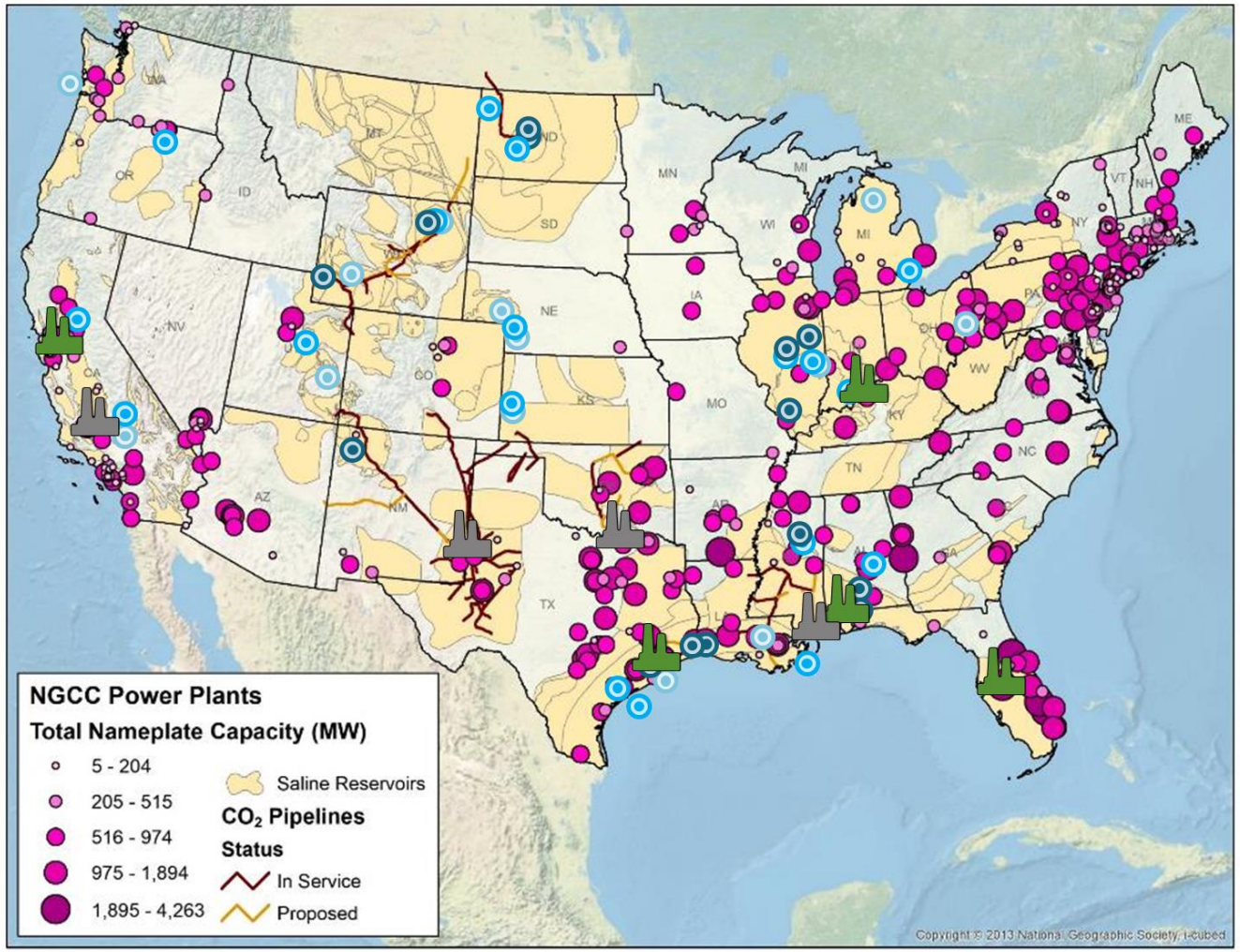








NGCC FEEDs



Carbon Capture FEEDs

- Active
- Completed

CarbonSAFE

- Phase I: Pre-Feasibility
- Phase 2: Feasibility
- Phase 3: Site Characterization and CO_2 Capture Assessment

Pilot Testing at TCM

RTI Non-Aqueous Solvent

12 MW

- ✓ >2,800 hours testing of RCC and NGCC flue gases
- ✓ Achieved target SRD's
- ✓ >99% capture CO_2 from NGCC
- ✓ Operated below emission limits using PTR-TOF-MS

Sorbent (TDA) + Membrane (MTR)

1MW

- ✓ Hybridization of membrane with sorbent reduces overall energy intake, lowering OPEX & CAPEX, and increasing net plant efficiency
- ✓ 4,000+ hrs… 87.% capture
- ✓ 1,450+ hrs.. 90% capture
- ✓ 307 hours.. >95% capture.

Purposed Built Pilots

Project Enterprise (ION)

1 MW

- 10 tpd CO_2 pilot on a 1 MWe slipstream flue gas
- NGCC power plant, Calpine's Los Medanos Energy Center, CA
- MEA, ICE-21 and ICE 31 solvents testing

✓ System Commissioned and ready for use

Chevron Natural Gas Carbon Capture Technology Testing Project

25 tpd CO_2

- Chevron's Kern River oil field San Joaquin Valley, CA USA
- Skid-mounted modular design of second-of-a-kind (SOAK) Svante capture plant

✓ Full site commissioning completed

✓ Plant Start-up and Ramp-up completed

- Operation of the 14% CO_2 Flue Gas: testing in progress

PSC Power: What's Next

Focus Area 1: Support Power Retrofit Demos

- Enabling technologies

Focus Area 2: Net Zero, Flex Power

- Technology development to support flexible CCS with high capture efficiency
- FEEDs to seed the formation of Carbon Hubs.

FOA 2614 Round 3: Reviewing applications

***AOI 3A**: Front-End Engineering Design Studies for Carbon Capture Systems at Existing (Retrofit) Domestic Natural Gas Combined Cycle (NGCC) Power Plants*

***AOI 3C:** Engineering-Scale Testing of Transformational Carbon Capture Technologies for Natural Gas Combined Cycle (NGCC) Power Plants*

FINANCIAL ASSISTANCE
FUNDING OPPORTUNITY ANNOUNCEMENT

Department of Energy (DOE)
Office of Fossil Energy and Carbon Management (FECM)

CARBON MANAGEMENT
Funding Opportunity Announcement (FOA) Number: DE-FOA-0002614

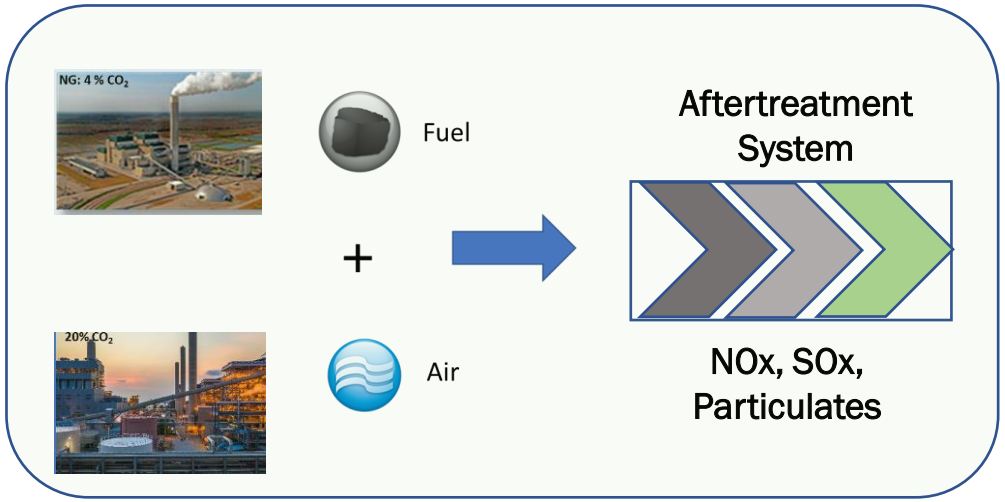
AOI-1. Carbon Conversion Technology
The objective of AOI-1 is to support R&D investigating the conversion of carbon dioxide (CO_2) into environmentally responsible and economically feasible products.

AOI-2. Carbon Dioxide Removal Technology
The objective of AOI-2 is to solicit applications that develop carbon dioxide removal (CDR) technologies (e.g., direct air capture with durable storage,
biomass carbon removal and storage, enhanced mineralization, ocean-based CDR, terrestrial sequestration) to support progress towards achieving the U.S. Department of Energy's Carbon Negative Shot target

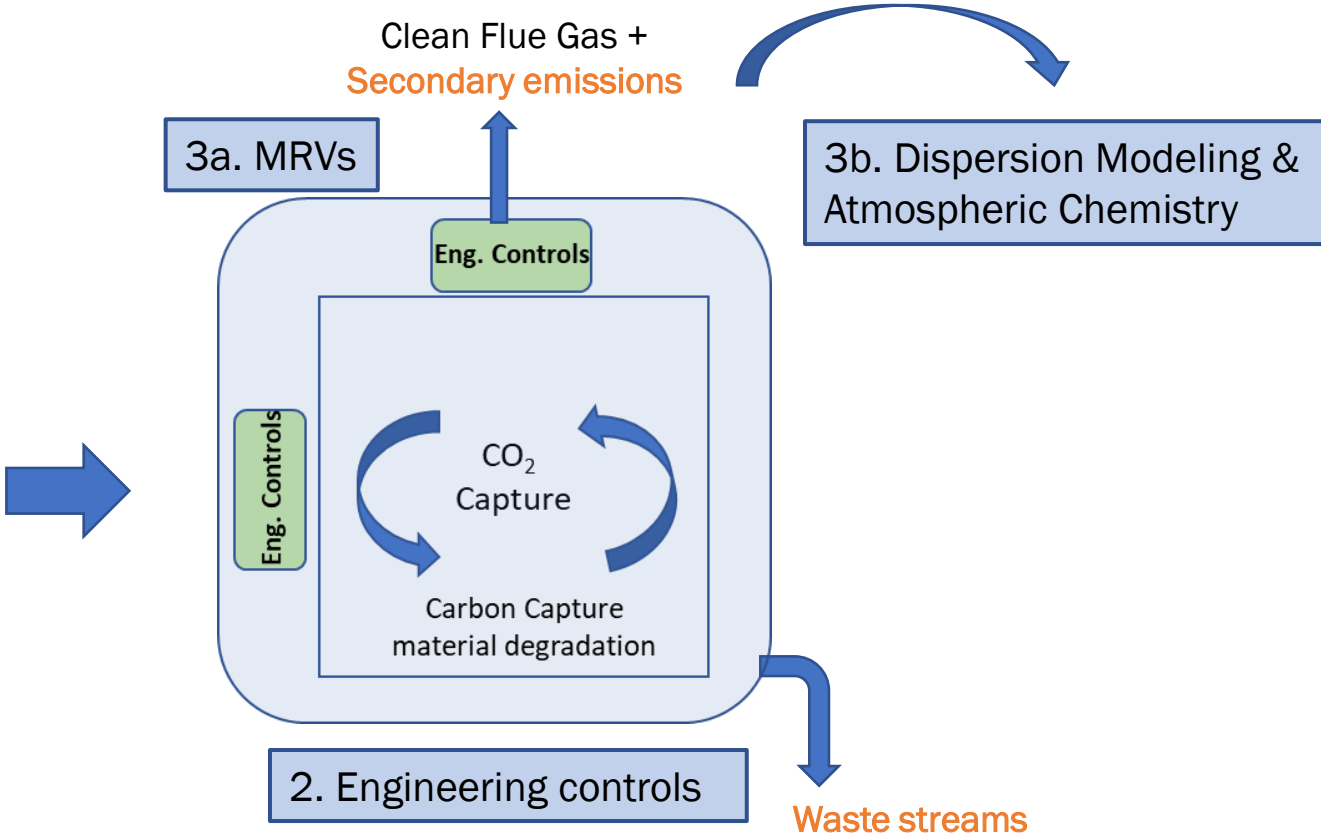
AOI-3. Point Source Carbon Capture
The objective of AOI-3 is to solicit applications that are specifically focused on developing lower cost, highly-efficient, technologies for point source capture from fossil fuel power plants and industrial point sources.

AOI-4. Carbon Storage Technology
AOI-4 aims to support resource assessments to securely store large amounts of CO2.

Measurement, Monitoring and Controlling Potential Environmental Impacts from the Installation of Point Source Capture



1. Impact of fuel, duty cycle, aftertreatment operation



2. Engineering controls

[Workshop on Measurement, Monitoring and Controlling Potential Environmental Impacts from the Installation of Point Source Capture | USEA | United States Energy Association](#).

PSC Collaboration Across Carbon Management

Carbon Transport and Storage

Targeted Capture FEEDs

Carbon Conversion

Reactive Capture for Industrial Decarb

Carbon Dioxide Removal

Leverage DAC / BiCRS technologies
High Capture Efficiency &
Industrial Decarb

FLExible Carbon Capture and Storage (FLECCS)
Annual Program Review

Jack Lewnard, Program Director

Jack.lewnard@hq.doe.gov

FLECCS Program

Phase 1

- 18 months, $11.5MM, 12 teams
- Modeling studies and economics based on future dispatch scenarios

Phase 2

- 36 months, $33MM, 6 teams
- Lab to large pilot demonstrations focused on carbon capture system
  - Some system-level integration, but this is a topic that needs more investigation
- Princeton modeling future dispatch scenarios
- Kickoff meeting September 19th in DC

FLECCS technology teams

Georgia Tech — NGCC CCS integrated with DAC using novel contactor

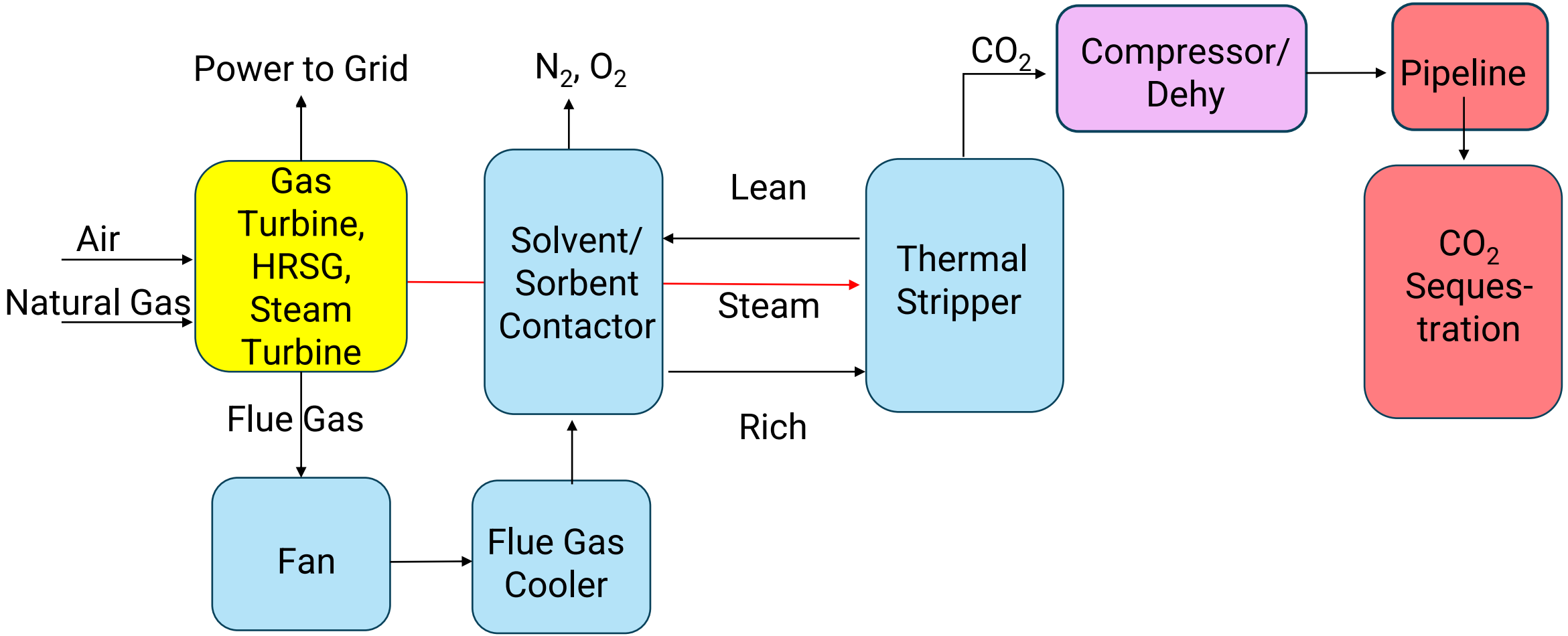
RTI INTERNATIONAL — Low-water solvent and rotating packed bed contactor

LUNA — Active transport ceramic membrane integrated into HRSG

Envergex Sparking Innovations — Novel sorbent with integrated storage/regeneration

8 RIVERS 8 Rivers Capital, LLC — Novel solvent with proprietary adsorber

Generic NGCC/CCS Flowsheet

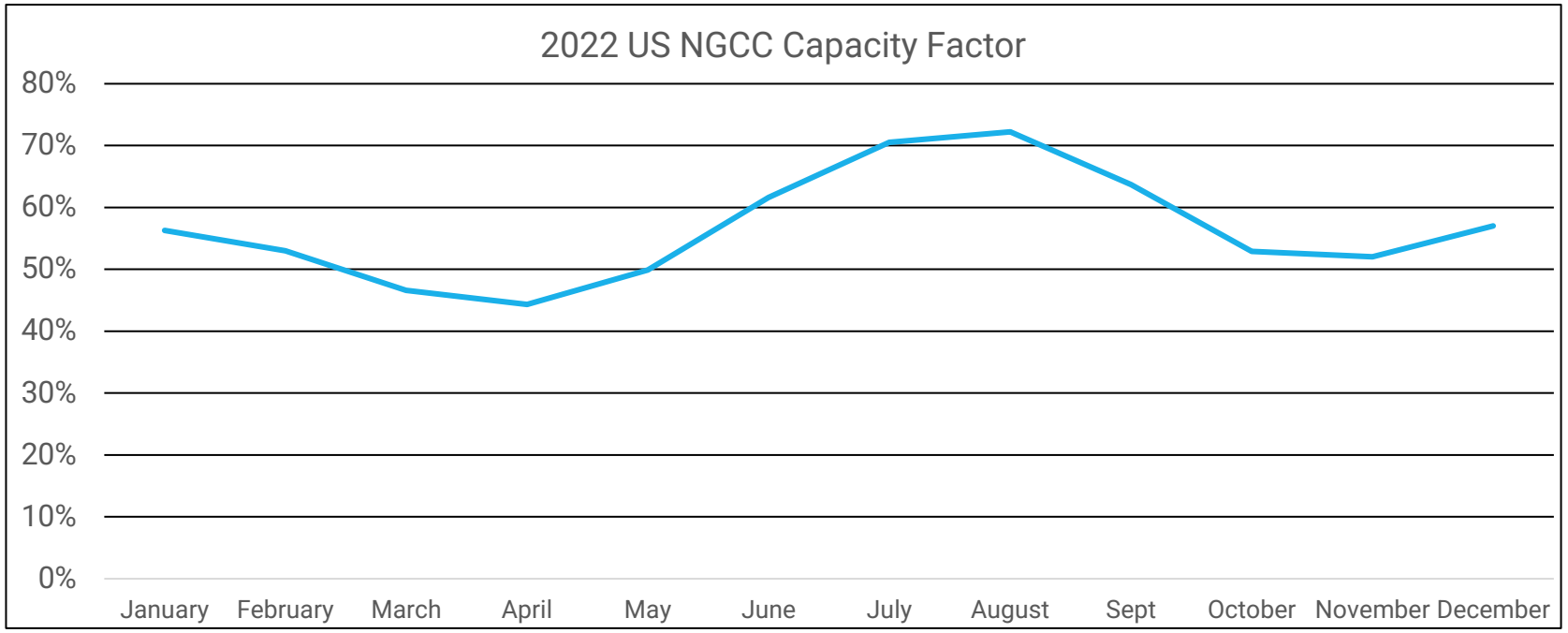


What Makes FLECCS ARPA-E Hard?

- "In 2019, the average number of starts for combined cycle plants was 39 per year. Just three years later, it's likely to hit 70, and the average could break 100 by 2023."

  Power Magazine, Aug 1, 2022

- NGCCs ramp up/down while operating



https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_6_07_a

The Whole is Greater than the Sum of its Parts

Physical Limits Addressed in FLECCS

- Pressure drop
  - Backpressure on gas turbine/HRSG needs to be <10 inches water (0.3 psi) during all operating transitions
- Steam
  - NGCC steam turbines do not have steam extraction ports
  - Regen steam requirements may exceed steam turbine operating range
- Space
  - Area CCS system ~ area to NGCC plant or larger
- CO_2 purity, esp non-condensable gases, must be consistent throughout operating range

The Whole is Greater than the Sum of its Parts

System-level challenges beyond FLECCS

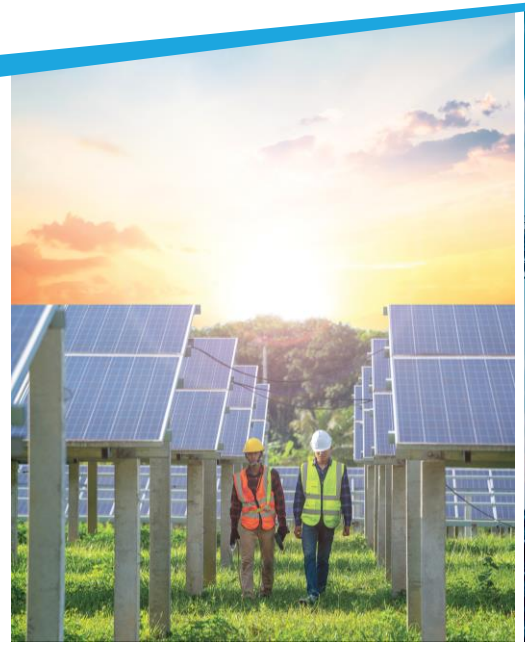
- Dispatch
  - Plants may run 2-24 hr/day, offline for multiple days esp. during shoulder months
- Size of system
  - NGCC ~ 300-1000 MW
    - Flue gas flow rate 1-3 MM kg/hr (0.5-2 BCFD); CO_2 150-500 ton/hr
  - Largest NG processing plants and LNG facilities have amine units that process similar mass, but at >30X higher pressure/<30X lower gas volumetric flow
- Dynamics for the components
  - NGCC ramp to full rate in <1 hr
  - 100-500 ton/hr CO_2 compressor/dehy need hours to ramp up
  - Amine absorbers need hours to a day to ramp up and may not turn down to min GT rate
  - Rapid flowrate changes may challenge CO_2 pipeline and downstream sequestration

Summary

- CCS retrofit to NGCC plants is hard, esp due to intermittent operation
- FLECCS evaluating novel carbon capture systems
- Recommend DOE consider further system-level issues

Office of Clean Energy Demonstrations






Carbon Capture Demonstrations Overview

FECM Project Review

August 28, 2023

Liz Moore, Program Manager

Liz.Moore@hq.doe.gov

Provision Overview – Carbon Capture Demonstrations

$2.5B

$937M FY 22
$500M FY 23 and FY 24
$600 M FY 25

- Establish a demonstration program through a competitive, merit-reviewed process,
- Enter **into cooperative agreements by not later than September 30, 2025**, for demonstration projects to demonstrate the construction and operation of **6 facilities to capture carbon dioxide from coal electric generation facilities (2 projects), natural gas electric generation facilities (2 projects), and industrial facilities (2 projects).**

Each demonstration project:
(i) shall be designed to further the development, deployment, and commercialization of technologies **to capture and sequester** carbon dioxide emissions from **new and existing** coal electric generation facilities, natural gas electric generation facilities, and industrial facilities;
(ii) shall be financed in part by the private sector; and
(iii) if necessary, shall secure agreements for the offtake of carbon dioxide emissions captured by qualifying technologies during the project.

CCS Demo FEED FOA 2738 Selections – Announced May 2023

Duke Energy Indiana, LLC

Edwardsport Flex Fuel Integrated Capture for Indiana's ENergy Transition (EFFICIENT) | Edwardsport, Indiana

Entergy Services, LLC (ESL)

Lake Charles Power Station Integrated CO2 Capture Project | Westlake, Louisiana

Heidelberg Materials (Lehigh Hanson, Inc.)

Mitchell Cement Plant Integrated CO2 Capture Project | Mitchell, Indiana

Membrane Technology and Research, Inc. (MTR)

Integrated Carbon Capture and Storage Project at Dry Fork Station | Gillette, Wyoming

Navajo Transitional Energy Company, LLC (NTEC)

Four Corners Power Plant Integrated Carbon Capture and Storage | Navajo Nation

Southern States Energy Board

Ash Grove Foreman Cement Plant Carbon Capture and Storage | Foreman, Arkansas

Taft Carbon Capture, LLC

Cypress Carbon Capture Project | Hahnville, Louisiana

Tampa Electric Company

Polk Power Station Integrated CO2 Capture Project | Mulberry, Florida

University of Illinois at Urbana-Champaign

Integrated Capture, Transport, and Geological Storage of CO2 Emissions from City Water, Light and Power | Springfield, Illinois

CCS Demo – "FOA 2"

DE-FOA-0002962: BIPARTISAN INFRASTRUCTURE LAW CARBON CAPTURE DEMONSTRATION PROJECTS PROGRAM

- FOA Closed: August 23, 2023
- Selection Announcement & Initiate Negotiations: late 2023
- Up to $1.7 billion DOE
- Construction & Operations Phases

Provision Overview – DAC Hubs

- DOE to invest $3.5 billion to accelerate the commercialization of the capture and sequestration or utilization of carbon dioxide captured from the atmosphere through grants, cooperative agreements, or contracts
- DE-FOA-0002735 managed via FECM/NETL & OCED
- Establish four regional direct air capture (DAC) Hubs
  - Each Regional DAC Hub shall
    - Facilitate the deployment of direct air capture projects
    - Have the capacity to capture and sequester, utilize, or sequester and utilize at least 1,000,000 metric tons of carbon dioxide from the atmosphere annually from a single unit or multiple interconnected units
    - Demonstrates the capture, processing, delivery, and sequestration or end-use of captured carbon
    - Could be developed into a regional or interregional carbon network to facilitate sequestration or carbon utilization
- Selections announced August 2023
  - 1PointFive | South Texas DAC Hub | Kleberg County, TX
  - Project Cypress | Project Cypress | Calcasieu Parish, LA

Regional DAC Hubs:

- Up to $50,000,000 per project (DOE, Phase 2 only)
- Down-select – Potential for up to additional $1,000,000,000 available for Phases 3+4

Provision Overview - Carbon Capture Large-Scale Pilot Projects

- Supports the development of **transformational technologies** that will significantly improve the efficiency, effectiveness, costs, emissions reductions, and environmental performance of coal and natural gas use, including in manufacturing and industrial facilities
- Unlike 41004(b), 41004(a) **does not specify** how pilots should be allocated
- FOA closed 7/7/23, DOE funding available: $820,000,000

A large-scale pilot project is large enough:

(i) to validate scaling factors; and

(ii) to demonstrate the interaction between major components so that control philosophies for a new process can be developed and enable the technology to advance from large-scale pilot project application **to commercial-scale demonstration or application**.

Includes references to 962(b)(2)(B) of the Energy Policy Act of 2005 (42 U.S.C. 17 16292(b)(2)(B))

Pathways to Commercial Liftoff

Pathways to Commercial Liftoff represents a new DOE-wide approach to deep **engagement between the public and private sectors**.

The initiative's goal is **catalyzing commercialization and deployment of technologies** critical to our nation's net-zero goals.

Pathways to Commercial Liftoff started in 2022 to:

- **collaborate, coordinate, and align with the private sector** on what it will take to commercialize technologies
- provide a **common fact base** on key challenges (e.g., cost curve)
- establish **a live tool and forum** to update the fact base and pathways

Publications and webinar content can be found at **Liftoff.energy.gov**

Feedback is eagerly welcomed via **liftoff@hq.doe.gov**

Thank You!

- Dan Hancu
  FECM
  Division Director, Point Source Carbon Capture
  Dan.Hancu@hq.doe.gov

- Jack Lewnard
  ARPA-E
  Program Director, FLECCS
  Jack.Lewnard@hq.doe.gov

- Liz Moore
  OCED
  Program Manager, Carbon Capture Demonstrations
  Liz.Moore@hq.doe.gov