



Industrial Decarbonization Panel

Tuesday, August 6, 4:00-5:00 PM

Moderator: Mani Gavvalapalli

Panelists:

Mani Gavvalapalli

Program Manager for Carbon Capture
Office of Fossil Energy and Carbon
Management (FECM)

Krista Hill

Federal Project Manager
National Energy Technology Laboratory (NETL)

Michael O'Connor

Portfolio Strategist
Office of Clean Energy Demonstrations
(OCED)

Celina Harris

Technology Manager
Industrial Efficiency and Decarbonization
Office (IEDO)

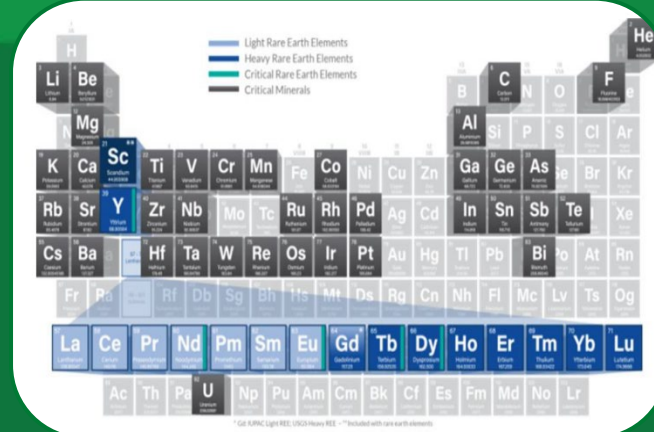


U.S. DEPARTMENT OF
ENERGY

Fossil Energy and
Carbon Management

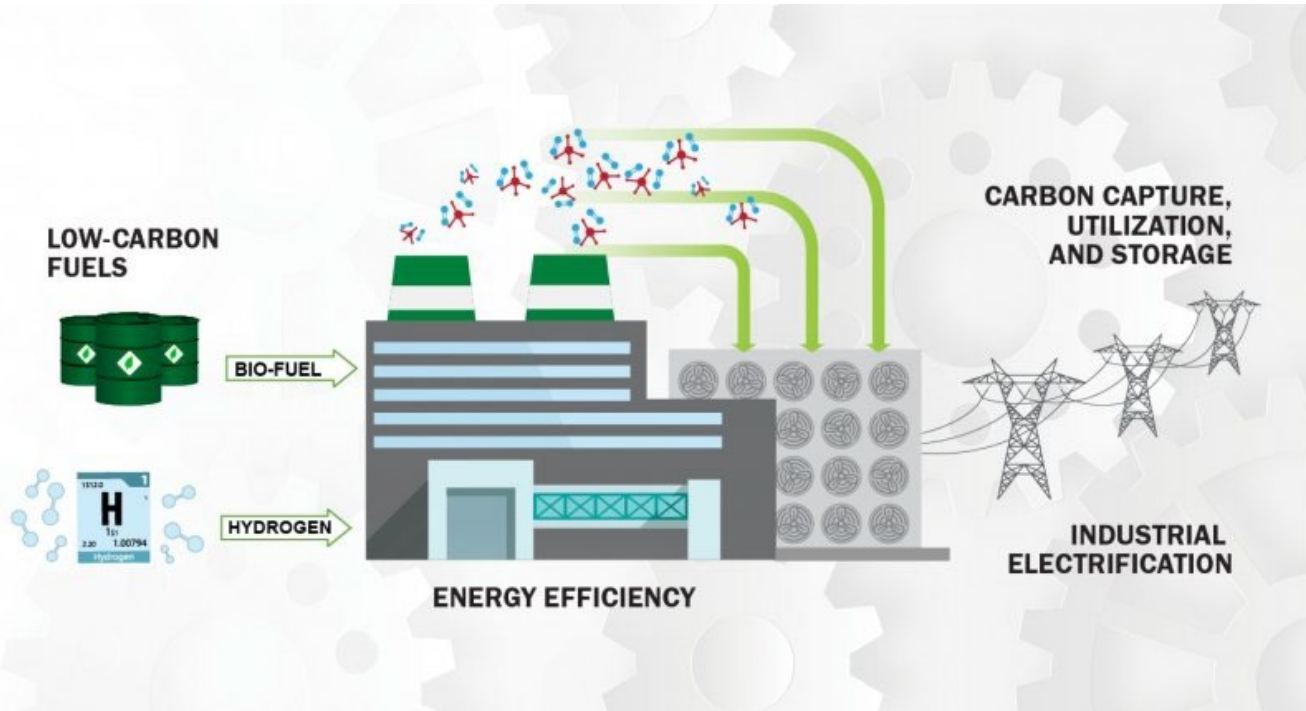
FECM Industrial Decarbonization Portfolio

Mani Gavvalapalli, Ph.D.
Program Manager, Point Source Capture
August 06, 2024



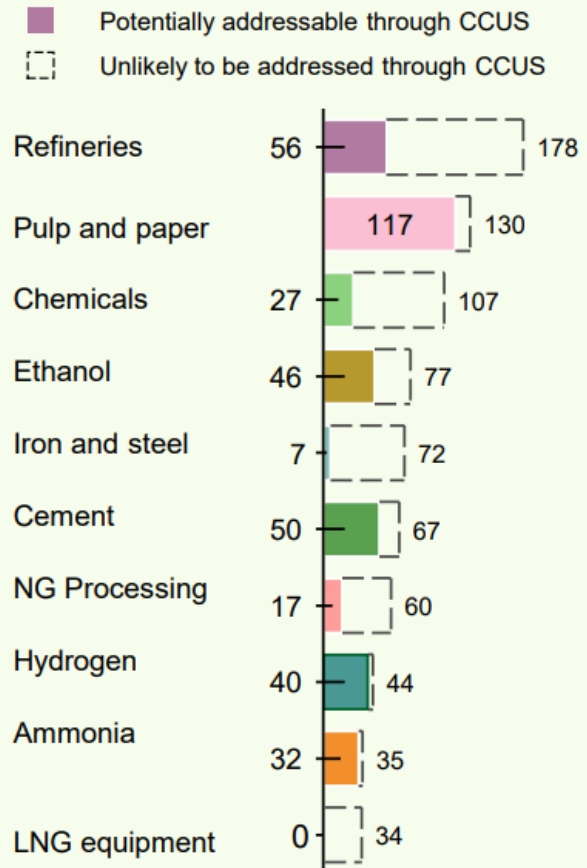
CCUS is Essential to address Industrial Emissions...

Strategies for Decarbonizing U.S. Industries



2022 Industrial Decarbonization Roadmap

Point source CO₂ emissions by sector¹, MTPA



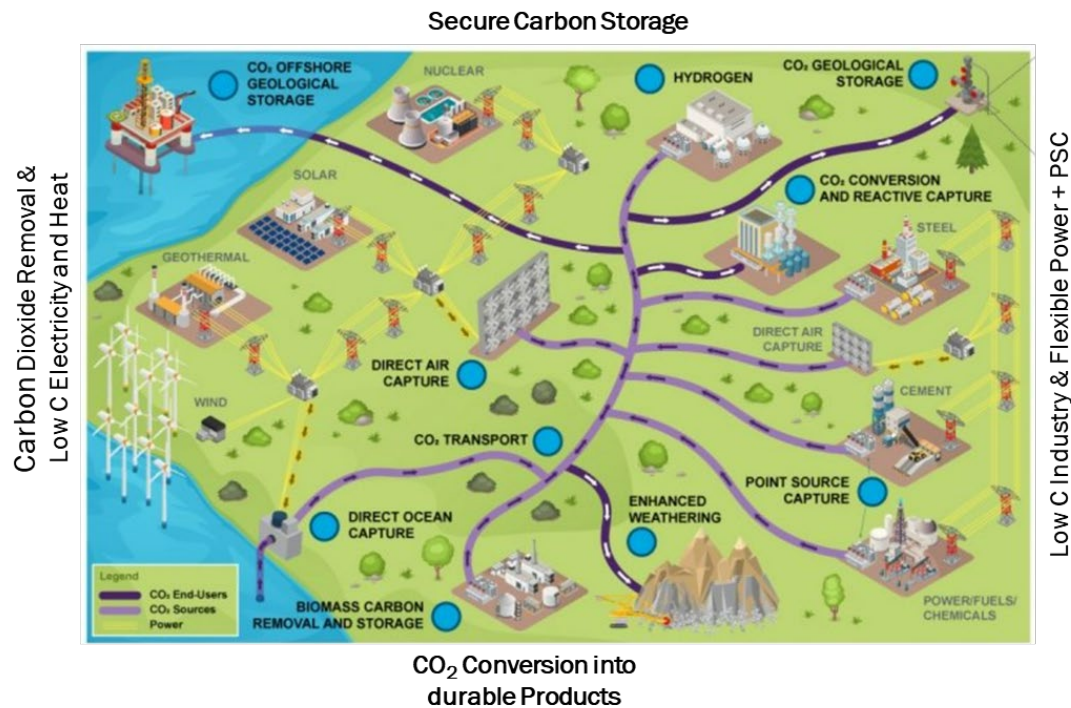
~2,500 facilities

10 sectors

liftoff.energy.gov

PSC Strategic Vision

Support demonstration of first-of-a-kind carbon capture on power and industrial sectors coupled to dedicated and reliable carbon storage, that will lead to commercially viable carbon hub opportunities 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

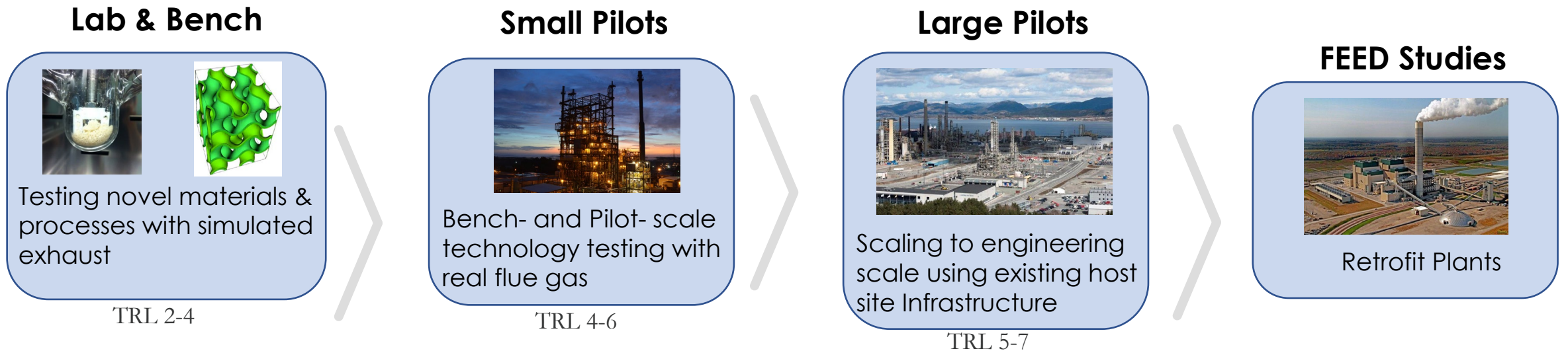
- Enabling technologies

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 Program - Industrial Decarbonization

Focus Area 3: Technology development to support successful demonstration of retrofit CCS projects at industrial facilities, including measuring, monitoring, and controlling CCS-related environmental impacts to ensure just and sustainable deployment

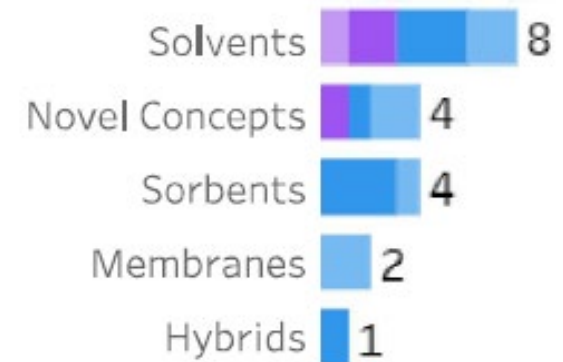


- Industrial Sectors:**
- Cement & Lime
 - Iron & Steel
 - Pulp and paper
 - Glass
 - Refining and Petrochemicals
 - Hydrogen/SMR



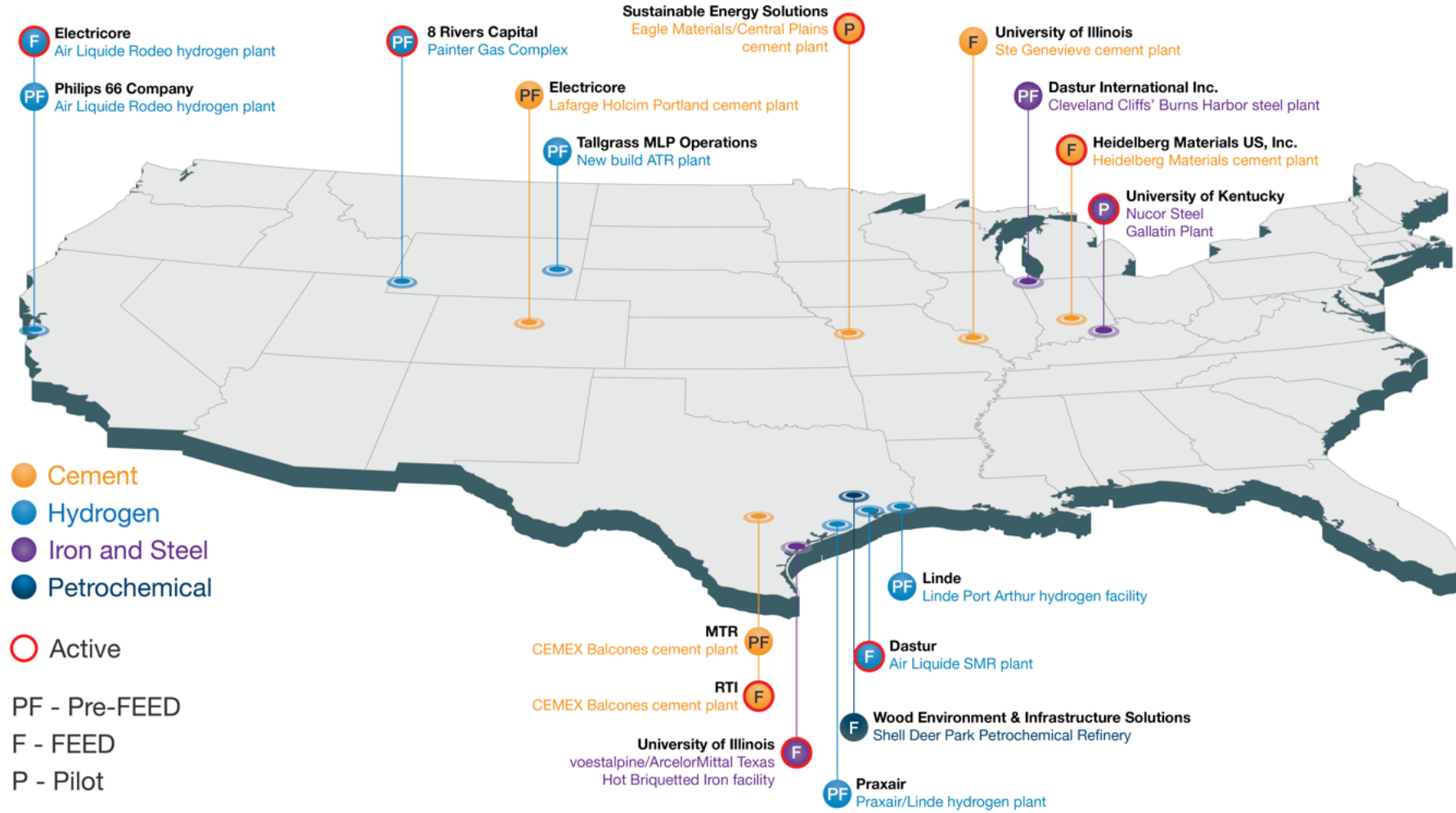
Investing in Transformational Capture Technologies

- Capture Media:
 - Amine-based solvents – most common and mature
 - Advanced solvents – water-lean solvents
 - Membranes
 - Cryogenic
 - Solid Sorbents
- Measuring, monitoring, and controlling CCS-related environmental impacts
- Process intensification; heat integration; modular capture units; mobile capture units; reactive capture
- Oxygen-based approaches (Oxy-combustion and Chemical Looping)



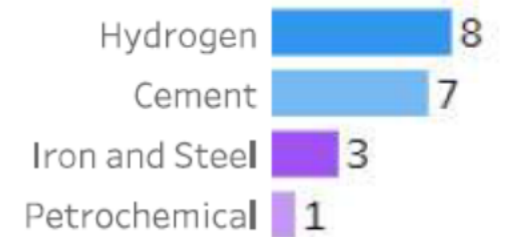


FECM Industrial Portfolio..



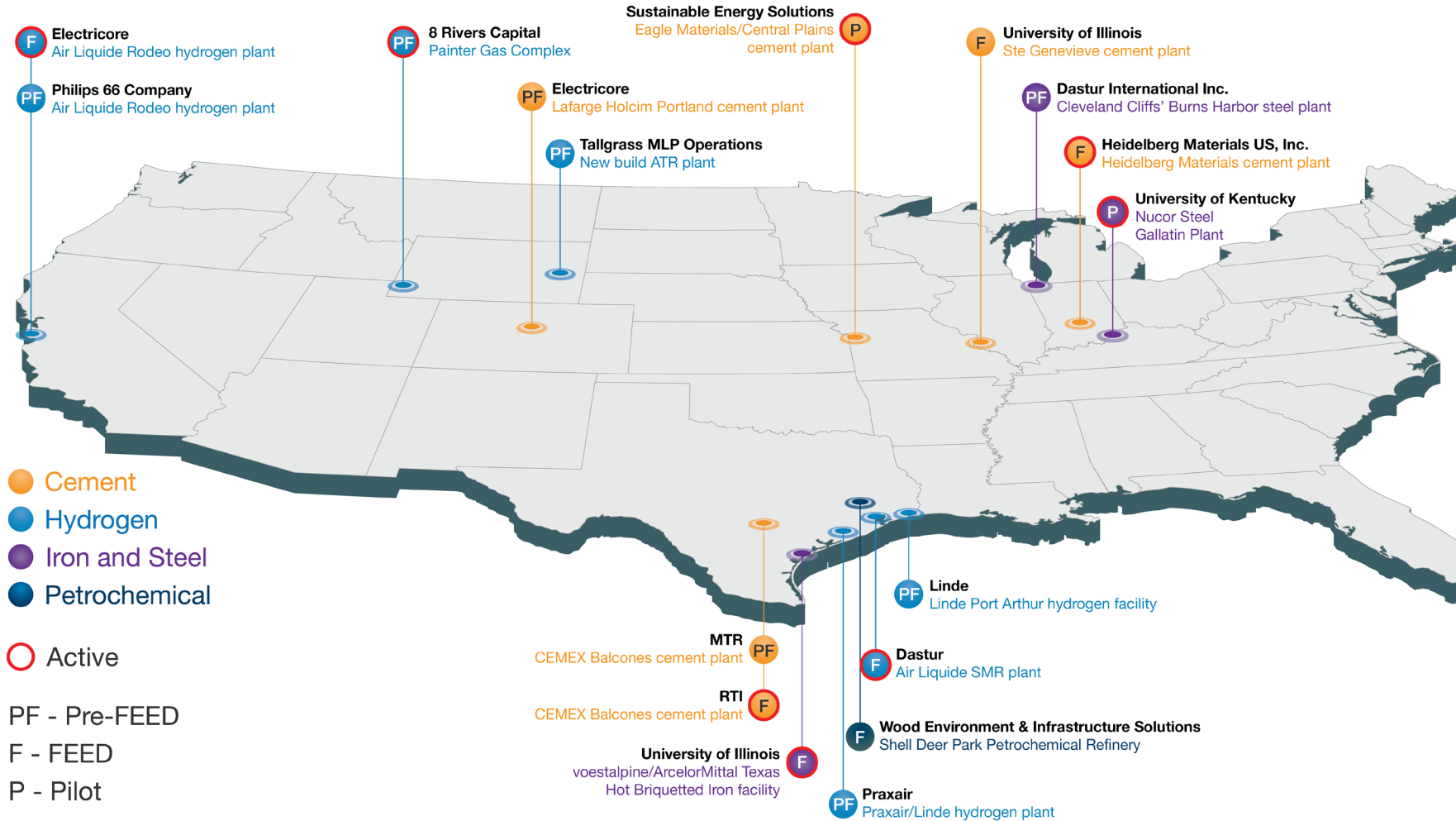
- 19 Projects total
- 9 pre-FEEDs, 7 FEEDs, and 2 pilots

Application Type



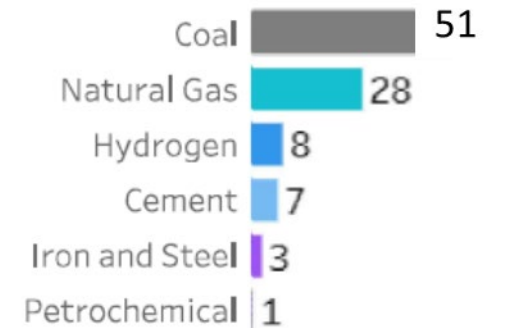


FECM Industrial Portfolio..



- 19 Projects total
- 9 pre-FEEDs, 7 FEEDs, and 2 pilots

Application Type



Expanding our Industrial Portfolio..

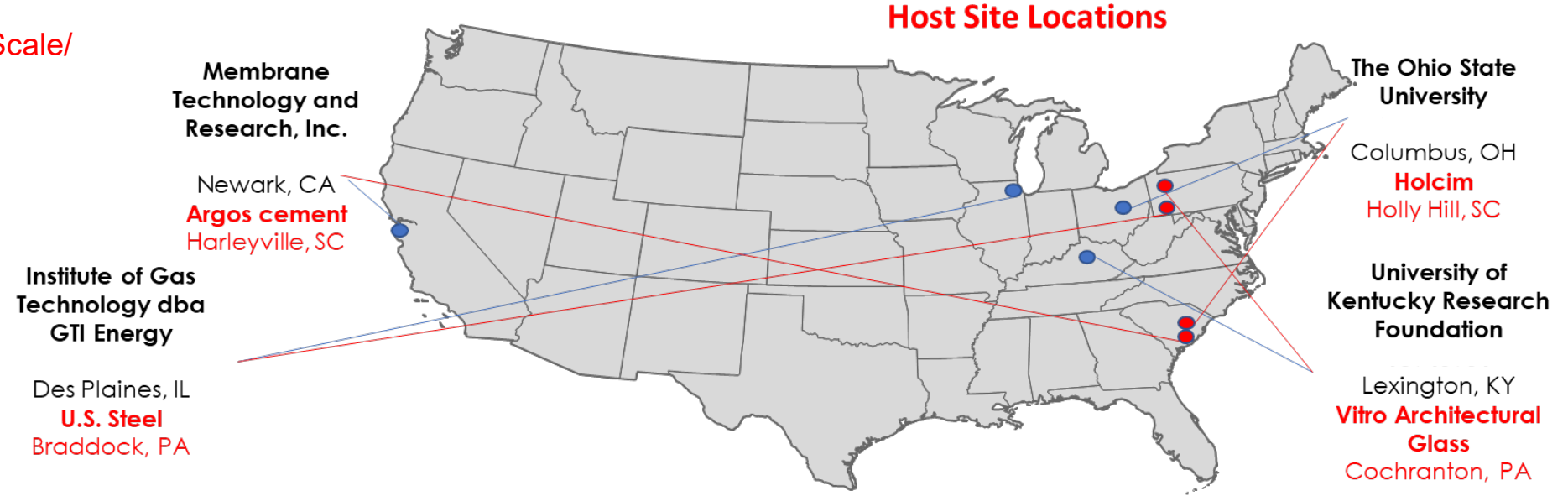
Project Selections for FOA 2614: Carbon Management (ROUND 3)

Area of Interest (AOI) 3A – Engineering-scale testing of transformational carbon capture technologies for industrial plants

Wednesday, August 7

2614 Round 3 Kickoff - Engineering-Scale/
Pilots (Power and Industrial)

4:25 - 4:55 p.m.	Mike Fasouletos - NETL Ron Munson - NETL Ben Omell - NETL
4:55 - 5:20 p.m.	Brief Presentations

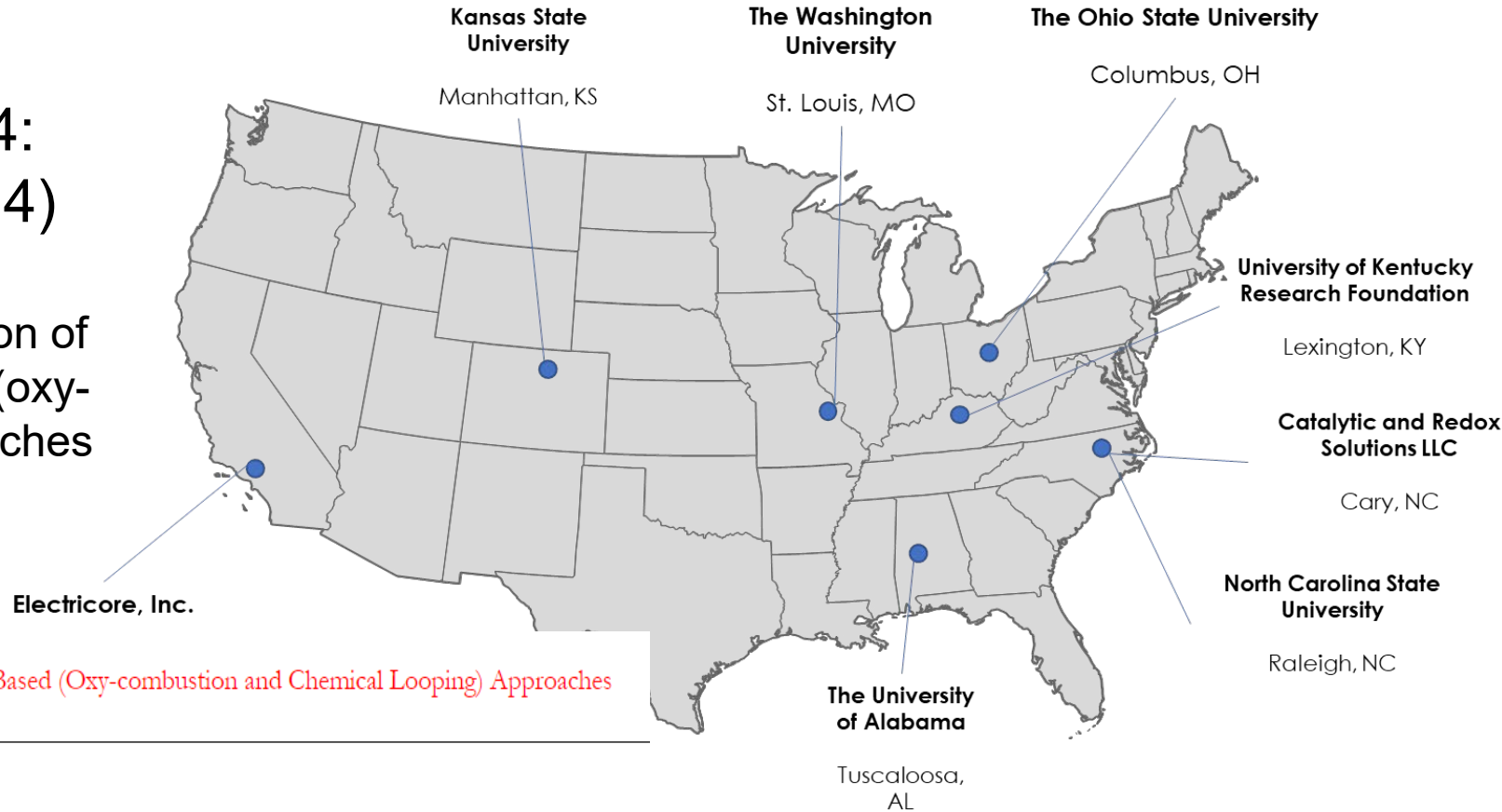




Expanding our Industrial Portfolio..

Project Selections for FOA 2614: Carbon Management (ROUND 4)

Area of Interest (AOI) 3D – Decarbonization of industrial processes using oxygen-based (oxy-combustion and chemical looping) approaches



Thursday, August 8

2614 Round 4 Kickoff - Decarbonization of Industrial Processes Using Oxygen-Based (Oxy-combustion and Chemical Looping) Approaches

	Oxygen-Based Approaches Panel
4:00 p.m. -	Mani Gavvalapalli - FECM
4:30 p.m.	Ron Munson - NETL
	Mike Fasouletos - NETL
4:30 pm -	Brief presentations
5:30 pm	

Projects by Sector:

- Chemicals: 4
- Iron & Steel: 2
- Lime: 1
- Pulp & Paper: 1



Notice of Intent to Issue Funding Opportunity Announcement No. DE-FOA-0002614 “Carbon Management (ROUND 6)”

If issued, the potential funding opportunity is anticipated to include the following areas of interest (AOIs) for carbon capture:

- AOI-1F. **Reactive Carbon Capture Approaches** for Point Source Capture or Atmospheric Capture with Integrated Conversion to Useful Products.
- AOI-3F: Engineering-Scale Testing of Transformational Carbon Capture Technologies for Natural Gas Combined Cycle (NGCC) Power Plants.
- **AOI-3G: Engineering-Scale Testing of Transformational Carbon Capture Technologies in Portable Systems at Industrial Plants.**
- AOI-3H-a: Initial Engineering Design Studies for Carbon Capture Systems at Existing (Retrofit) Domestic NGCC Power Plants.
- **AOI-3H-b: Initial Engineering Design Studies for Carbon Capture Systems at Hydrogen Production Facilities** Using Coal, Mixed Coal/Biomass, or Natural Gas Feedstock.



Notice of Intent to Issue Funding Opportunity Announcement No. DE-FOA-0003365 “Carbon Capture, Removal, and Conversion Test Centers”

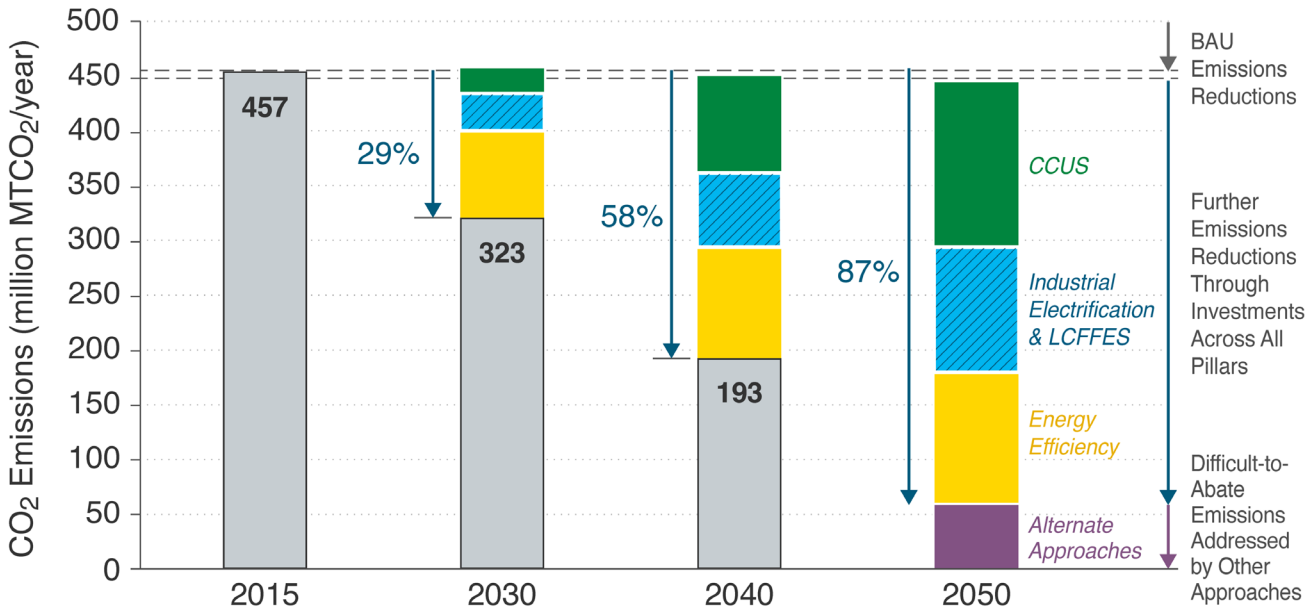
If issued, the potential funding opportunity is anticipated to include the following three areas of interest (AOIs):

- AOI 1: Carbon Capture, Removal, and Conversion Test Center at an Electric Generating Unit.
- AOI 2: Enabling Capital Improvements at an Existing Carbon Capture Test Center.
- AOI 3: Carbon Capture, Removal, and Conversion Test Center at a **Cement Manufacturing Facility.**



PSC Program - Industrial Decarbonization

Focus Area 4: Support Integrated Industrial Decarbonization projects that combine other decarbonization approaches with CCS in collaboration with other DOE Offices



- Remaining GHG Emissions
- Emissions Reduction by CCUS
- Emissions Reduction by Industrial Electrification & LCFES
- Emissions Reduction by Energy Efficiency
- Emissions Reduction by Alternate Approaches (e.g., Negative Emissions Technologies)

- Fuel switching + CCS
- Novel industrial processes + CCS

Industrial Decarbonization Roadmap



Technologies for Industrial Emissions Reduction Development (TIEReD) Program

U.S. Department of Energy (DOE)
Office of Energy Efficiency and Renewable Energy (EERE)

FY24 Energy and Emissions Intensive Industries FOA
Funding Opportunity Announcement (FOA) Number: DE-FOA-0003219

This FOA included a joint topic (IEDO/HFTO/FECM) soliciting pre-Front-End Engineering and Design (pre-FEED) studies for the integration of clean hydrogen and/or carbon capture with other decarbonization approaches in the industrial sector.

Topic 6: Industrial Pre-FEED Studies

- Area of Interest 1 – Integration of Clean Hydrogen in the Industrial Sector
- Area of Interest 2 – Carbon Capture for the Industrial Sector
- Area of Interest 3 – Integrated Process Pre-FEED (pre-FEEDs that integrate multiple innovative technologies including carbon capture, H₂, energy efficiency, electrification, process feed substitutions, process heating innovations, etc.)**

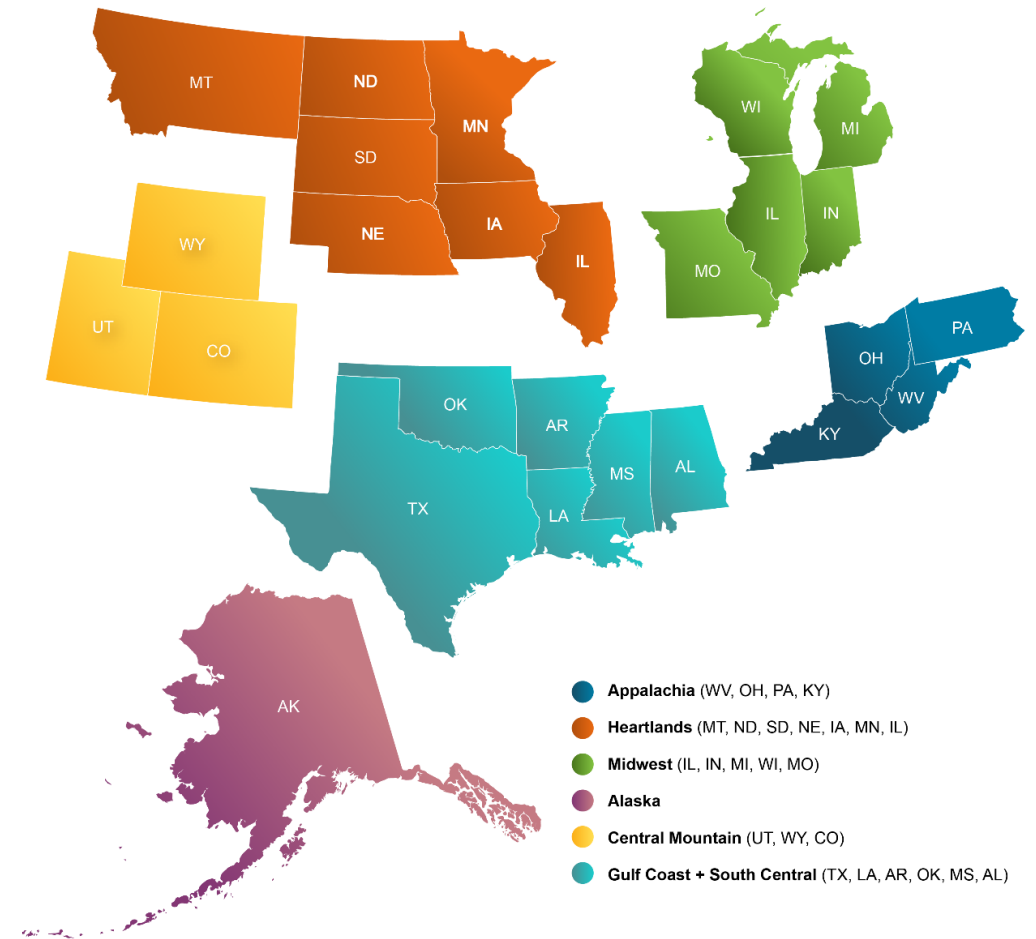


Regional Deploy Dialogues

Office of Fossil Energy and Carbon Management

Regional Reports: Building a Clean Energy and Industrial Economy and the Supporting Role of DOE's Office of Fossil Energy and Carbon Management

[FECM Regional Reports](#)



Appalachia GET READY FOR

DEMONSTRATE DEPLOY DECARBONIZE

Industrial Decarbonization
August 6, 2024

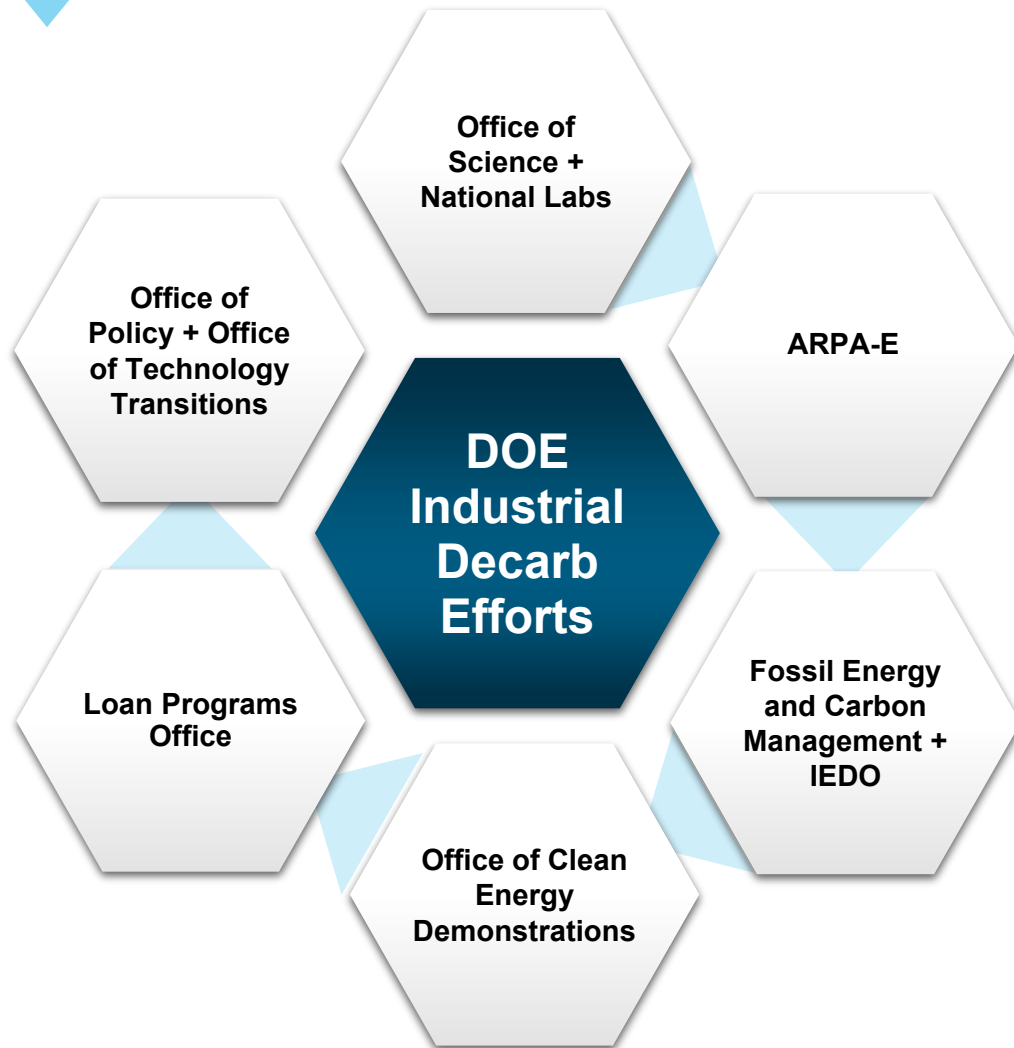
Register for Deploy24, today!
December 4-5, 2024
Washington, D.C.



Tuesday, August 6

5:00 - 5:20 p.m.	DOE Regional Focus on Decarbonization Melissa Stark - U.S. Department of Energy - FECM
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Industrial Decarbonization efforts across DOE



- Pathways to Commercial Liftoff Efforts
liftoff.energy.gov



- Industrial Heat Shot, Carbon Negative Shot, and Clean Fuels and Products shot
<https://www.energy.gov/energy-earthshots-initiative>
- Industrial technologies Joint Strategy Team (JST)
- Science and Energy Technology Team (SETT)

A collage of four images on the left side of the slide: an oil rig, scientists in a lab, field researchers, and a large array of solar panels.

Thank You!

Questions?

Mani Gavvalapalli

Program Manager, FECM
Point Source Carbon Capture
Mani.Gavvalapalli@hq.doe.gov

Dan Hancu

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

Request for Information (DE-FOA-0003263)

Industrial Deployment and Demonstration Opportunities for Carbon Capture Technologies



Summary of RFI Responses

August 6th, 2024



Solutions for Today | Options for Tomorrow



Objective

- This RFI sought input from key partners (domestic and international) on what is needed to accelerate deployment of CCUS for industrial systems to support the energy transition, eliminate greenhouse gas emissions, produce clean energy, create well-paying union jobs, and enable a net-zero carbon emissions economy by 2050, all while prioritizing environmental justice.
- DOE requested input related to the Scope 1 CO₂e emissions and their potential for mitigation using CCUS for specific industrial sectors
- The information collected may be used across DOE's research, development, demonstration, and deployment (RDD&D) portfolio, including, but not limited to, determining potential new areas of focus and innovation; identifying challenges and knowledge gaps; identifying funding opportunities; identifying regional opportunities; and determining the potential for clean energy and carbon management careers, all while considering potential impacts to local communities (including environmental justice and equitable energy transition).

Objective



Response Overview

- Industries Represented in Responses
 - Pulp and paper
 - Lime
 - Cement
 - Iron/Steel
 - Refining and Petrochemicals
 - Waste-to-energy
 - Liquefied Natural Gas (LNG)
 - Ammonia
 - Glass
 - Hydrogen/SMR
 - Soda Ash

Overall Summary

- **Primary capture technologies mentioned:**
 - Amine-based solvent, Membrane, Cryogenic
- **Anticipated quantity of CO₂ captured range:** 300,000 – 3,000,000 tonnes CO₂/year
- **TRL of technologies mentioned:** range from TRL 4 to TRL 9
- **CO₂ infrastructure:**
 - The lack of infrastructure for transport and storage is of major concern. (Sites being excluded due to lack of infrastructure.)
- **Policy development:** incentivize, increase tax credits, permitting.
- **Product price premiums:** customers are resistant to price premiums for low carbon materials.
- Fed. Government will be significant **market driver** for low carbon products through direct purchases.
- **Energy impacts:** Grid capacity for electricity and heat requirements of carbon capture.
- **Funding sources:** Combination of direct funding, tax credits, grants, and loans. (Increasing the 45Q credit.)

Common Themes from Industry-Specific Responses

General Comments All Industries:

- General interest in carbon capture and actively working towards CCUS implementation.
- Electrification and fuel-switching as the most immediate solution to lower emissions.
- New reactor designs needed to lower emissions and/or enable carbon capture.
- Space limitations at existing facilities.
- **Efficiency improvements:**
 - Lower carbon emitting fuels.
 - Decarbonized raw materials.
 - Renewable energy for plant operations.
 - Waste heat recovery.
 - Oxy-enrichment.

Cost-Effective Decarbonization Strategies

- Fuel switching, alternative fuel, decarbonized feedstocks, renewable energy, process energy efficiency improvements (today)
- CCUS and H₂ (2035)

Challenges

- Policy barriers and long-term policy stability.
- A single technology solution cannot be applied to all point sources.

Policy Development

- Incentivize first movers and pilot and demo projects.
- Introduce an Investment Tax Credit (ITC).
- Prioritize and expedite permitting for Class VI wells.

Trends

- Customers are becoming increasingly focused on importance of low-carbon construction.
- Product cost premium is disadvantageous for driving commercialization of low carbon products.
- Uncertainty of Class VI well permitting is an issue for timeline planning.
- Federal Government will be significant market driver for low carbon products.
- Ongoing education and engagement with the marketplace to accelerate low-carbon products acceptance.
- Hubs and voluntary carbon markets

Recommendations

- Government prioritize direct purchases of low-carbon products.
- Develop policies to support both supply and demand.
- Support regional hubs
- Remove regulatory barriers
- Enhance § 45Q

Energy impacts

- Large scale CC will require large amounts of heat and electricity.
- Renewable energy could add significant cost to projects.
- Pulling power from the grid likely the most economical solution from capital standpoint.
- Grid will need to handle the increase in demand due to CCUS systems.
- May need to consider on-site energy production.

Performance guarantees

- Technology performance guarantees are critical to de-risking project financials.
- The performance guarantee needs to confirm the technology can achieve the predicted performance over long periods.

Highlights

- Project funding will be a combination of direct funding, investments tax credits, grants, and loans.
- Federal funding is essential for projects to move forward.
- Two of the largest impact funding sources: 45Q credits & DOE OCED.
- Carbon pricing, cap and trade, and/or Carbon Border Adjustment Mechanism (CBAM) like in the EU would make the economics of these projects significantly more attractive and reliable.

Challenges

- Need clarity on long-term value of CO₂ offsets to support financing decisions.
- Need broad federal policy addressing CO₂ reductions.

- 45Q and 45V are not sufficient on their own to fully support low-carbon intensity product projects.
- 45Q and 45V application process is lengthy, complex, and resource consuming.
- 45V (utilization) tax credits lack some clarity and flexibility, and burdensome.
- 48C short application windows make it more difficult to apply and receive funding. Some were not aware of the tax credit.
- Tax credit policy 45Q:
 - Offer a \$100-\$150/tonne 45Q for hard-to-abate sectors.
 - Increase the duration of the tax credit and allow direct repay for the duration of the credit to provide better developer certainty.
 - Allow the credits to be traded more than once to allow more potential buyers into the market.
 - 45Q incentives are too low in value and too short in duration (12 years) for broad market adoption of CCS.
- Project developers would benefit from:
 - Higher incentives or credits in the early stages of technology deployment
 - Introducing an Investment Tax Credit (ITC) for capital expenditure (CAPEX).

Key Efforts

- Engage local communities as early as possible.
- Have dedicated staff.
- Establish relationships with anchor organizations embedded in the community.
- Identify interests outside of the community that may influence local decision making.
- Identify public sector leadership in CCUS, where communities and workers can own and co-create projects.

- Pipeline projects may face engagement challenges.
- Confidentiality agreements with industrial partners often prohibit crucial work of early engagement.

DOE Recommendations

- Increase awareness of CCUS and CDR technologies and their importance among the American public.
- Work closely with project developers to explain outcomes of CCUS projects including benefits.
- Justify the reasoning behind specific CCUS projects.
- Perform climate surveys, focus groups, needs assessments, and listening sessions.
- Make all CBPs public.
- Allow community organizations to comment on CBPs.
- Make CBPs legally binding as part of the award.

Key Efforts

- Build pipeline of future talent through outreach.
- Engage local colleges to educate students on net-zero technologies .
- Utilize existing skillsets.
- Build a communication strategy.

Recommendations

- Emphasize policies and programs to incentivize offering and undertaking of career/technical education.
- Need policies and programs from Federal Government to supplement private sector initiatives.

- **Remove regulatory barriers** to capture technology permits, expansion of electrical grid capacity, and CO₂ transport pipelines. **Expedite approval** and have **transparent timelines for Class VI storage primacy**.
- **Industrial decarbonization “hub” consortium is recommended** due to common goals of partners. Encourage **state and local governments to share in the funding** to support these initiatives.
- **Accelerate the offtake of low-carbon intensity products** by funding projects that include and develop the entire value chain. **Aggressive implementation of “BuyClean” and federal or state government procurement of low carbon goods** with a green premium would promote low carbon practices.
- A **buyer of last resort**, similar to the role of the Canada Growth Fund, can positively impact U.S. markets.



OCED
Office of Clean Energy Demonstrations

THE OFFICE OF CLEAN ENERGY DEMONSTRATIONS



Overview of Industrial Decarbonization Portfolio

Office of Clean Energy Demonstrations

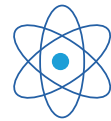
U.S. Department of Energy

August 2024



Office of Clean Energy Demonstrations

Deliver clean energy technology **demonstration projects at scale** in partnership with the **private sector** to **accelerate deployment, market adoption**, and the **equitable transition** to a decarbonized energy system.”



Advanced Reactor Demos (\$2.5B)



Industrial Demonstrations (\$6.3B)



Clean Energy on Mine Land (\$500M)



Long-Duration Energy Storage (\$505M)



Carbon Management (\$7B)



Regional Clean Hydrogen Hubs (\$8B)



Distributed Energy Systems (\$50M)



Liftoff Enabling Programs(\$133M)

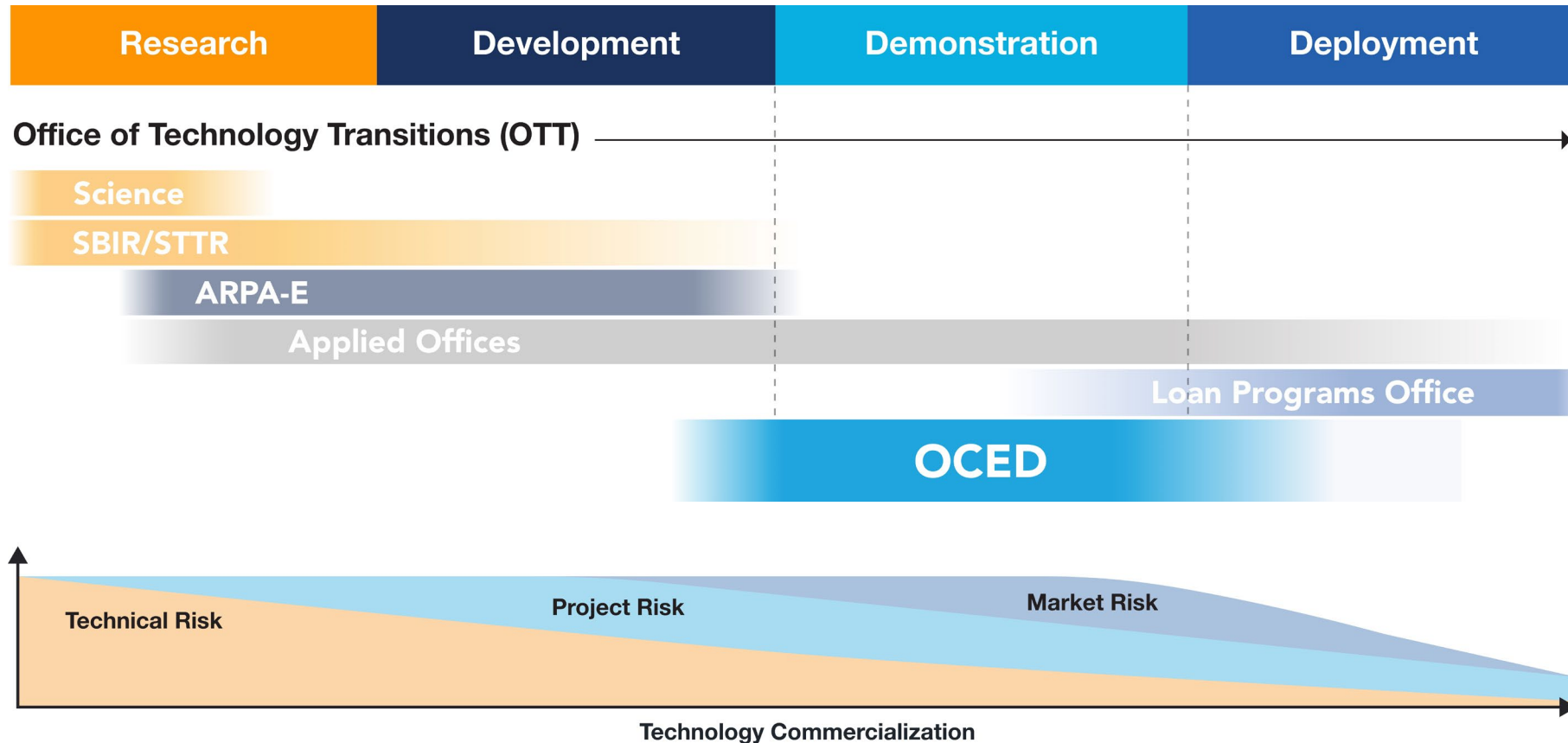


Energy Improvements in Rural or Remote Areas (\$1B)

OCED Role in the RDD&D Continuum

Focused on a specific stage of the RDD&D continuum – **Commercial Demonstrations:**

- Involve **more time, cost and risk than a prototype**, and
- **Significantly reduce investor risk** for subsequent installations.



SCALE EQUITABLE,
CLEAN ENERGY



UNLOCK NEW
INVESTMENT



DE-RISK
TECHNOLOGY



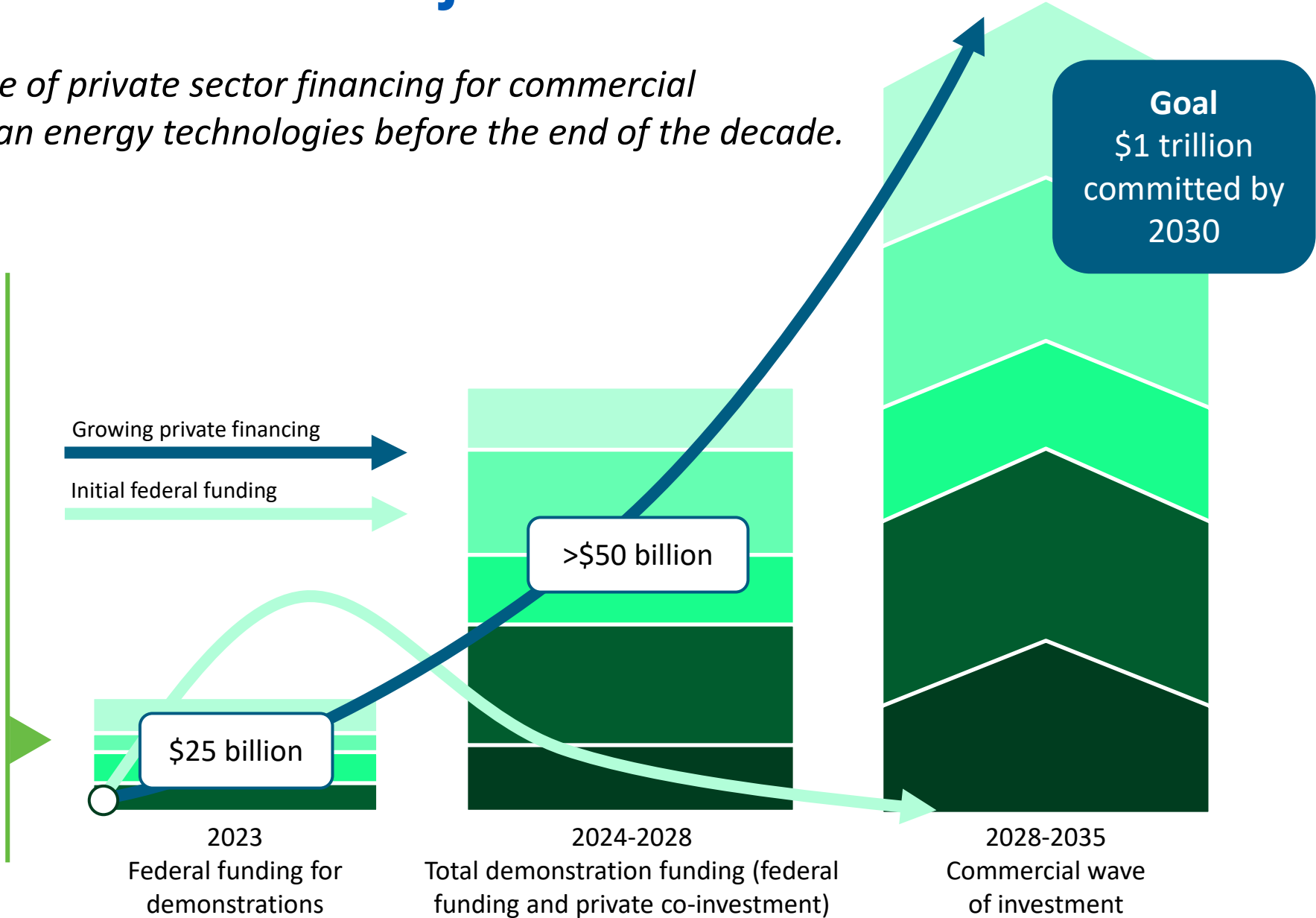
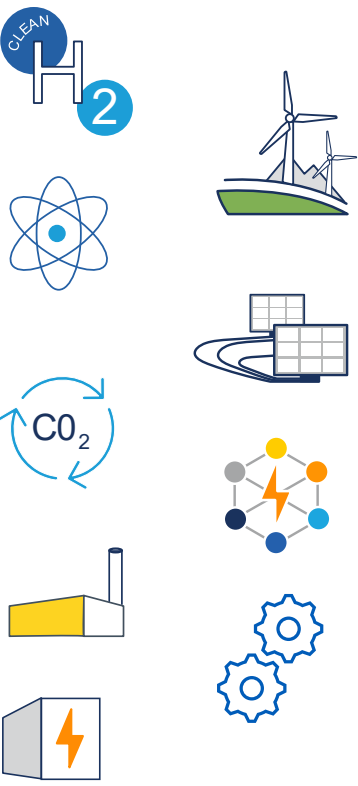
PROVIDE PROJECT
OVERSIGHT



ENGAGE &
COLLABORATE

The Mission is More Than the Projects Themselves

Focused on triggering a wave of private sector financing for commercial deployment of emerging clean energy technologies before the end of the decade.



\$20+ billion investment

for transformational, advanced industrial facilities to

Solidify a first-mover advantage for U.S. industry in low- and net-zero carbon manufacturing

Substantiate the market for clean products through high-impact, replicable solutions

Build broadly shared prosperity for American workers and communities

Across **hard-to-abate sectors** including:



Aluminum & Metals



Cement & Concrete



Chemicals & Refining



Process Heat



Food & Beverage



Glass & Ceramics



Iron & Steel



Pulp & Paper



Selectees Delivered on Ambitious Program Priorities



Deep Decarbonization

Target:
50 – 75% emissions reductions per project

Result:
Average **77% reduction** in carbon intensity & **~14+ million MT CO₂e reduced** annually



Timeliness

Target:
Accelerate decarbonization into this decade

Result:
Average performance period of **less than 6 years**



Market Viability

Target:
Spur follow-on investment in lower-embodied carbon goods

Result:
35+ products to be produced with lower embodied emissions; multiple with premium offtake agreements in place today



Community Benefits

Target:
Select projects with the greatest benefit for the greatest number of people

Result:
85% of projects improve air quality; investment will create **tens of thousands of jobs** across the United States

CEMENT & CONCRETE

6

projects

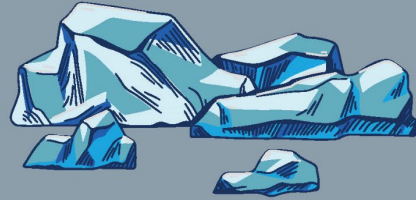
\$1.6B

federal investment

4M

metric tons CO₂
avoided annually

Traditional
Production



Limestone with embodied carbon –
released to the atmosphere
during manufacturing

Demonstrations

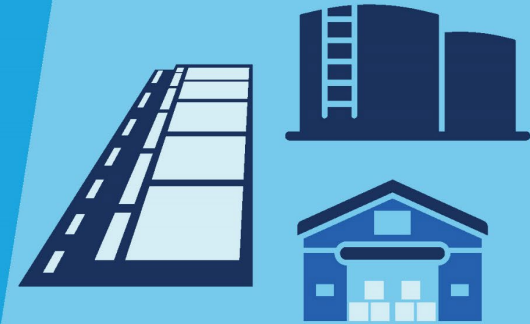


Silicate-based rocks like basalt replace limestone



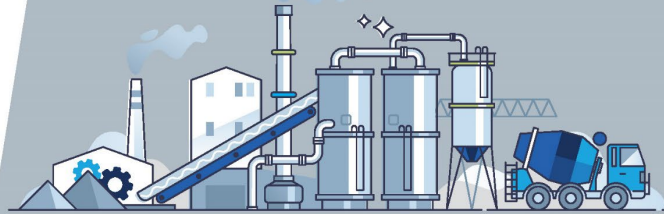
Clay calcined and blended to produce cement, de-
creasing the need for carbon-intensive limestone

Real World
Impact



Multiple decarbonized options for the most
widely used building material in the world

CO₂



Cement plant releases emissions to atmosphere

O₂

Oxyfuel



Pistachio
shells



Thermal
battery



Cement plant with carbon capture



MD



MA



GA



CA

Note: Anticipated based on information
provided to the Department of Energy as
of March 2024



OCED
Office of Clean Energy Demonstrations

IRON & STEEL

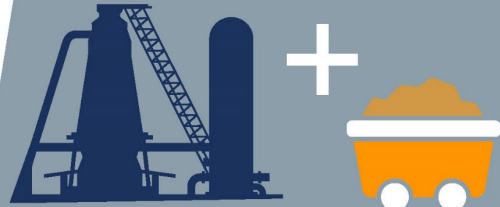
6 projects

\$1.5B federal investment

2.5M metric tons CO₂ avoided annually

Ironmaking

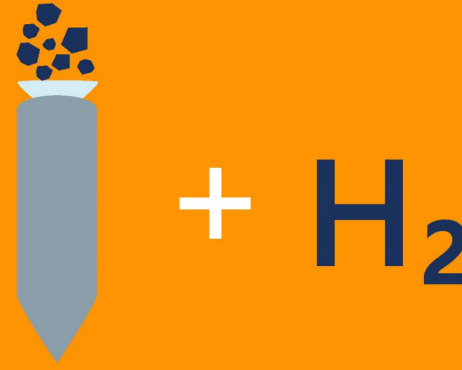
Traditional Production



Blast Furnace

Metallurgical Coke (from coal)

Demonstrations



Direct Reduced Ironmaking

Hydrogen

Real World Impact

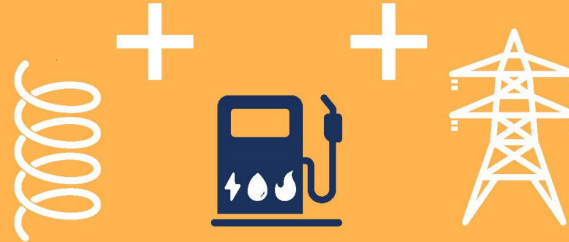


High Grades of Steel

Finishing Process



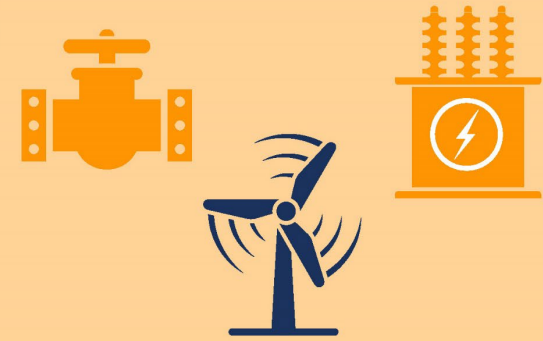
Heat from Fossil Fuels



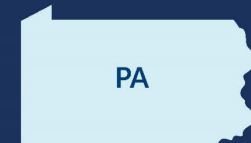
Induction

Flexible Fuels

Electricity



Resilient Infrastructure



Note: Anticipated based on information provided to the Department of Energy as of March 2024.



OCED
Office of Clean Energy Demonstrations

CHEMICALS & REFINING

& SEPARATIONS PROCESSES FOR PULP & PAPER

8 projects

\$1.3B federal investment

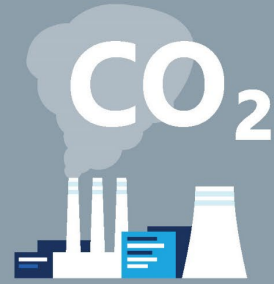
3M metric tons CO₂ avoided annually



Note: Anticipated based on information provided to the Department of Energy as of March 2024

Carbon Capture and Utilization
Value-Added Recycling
Process Heat

Traditional Production



Carbon process emissions released to the atmosphere



Waste landfilled or incinerated



Fossil-based high-temperature heat

Demonstrations



Carbon captured and routed to a new process for upcycling



Chemical byproducts and textiles recycled



Specialized, decarbonized burners
Thermal batteries powered by renewables
Membrane separation

Real World Impact



Fuels for marine transport
Polymers for apparel
Electrolytes for lithium ion batteries



High-quality plastics for food and medical applications
Decarbonized fuels



Major CO₂ emissions reductions and improved air quality for communities

ALUMINUM & METALS

5 projects

\$900M+ federal investment

4M+ metric tons CO₂ avoided annually



Note: Anticipated based on information provided to the Department of Energy as of March 2024

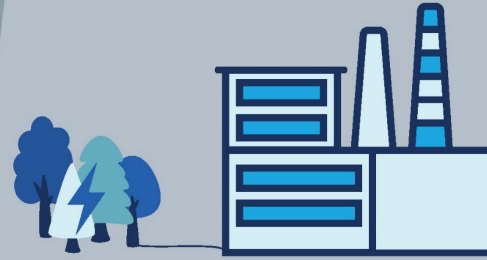
Primary Aluminum
Recycling
Process Heat

Traditional Production



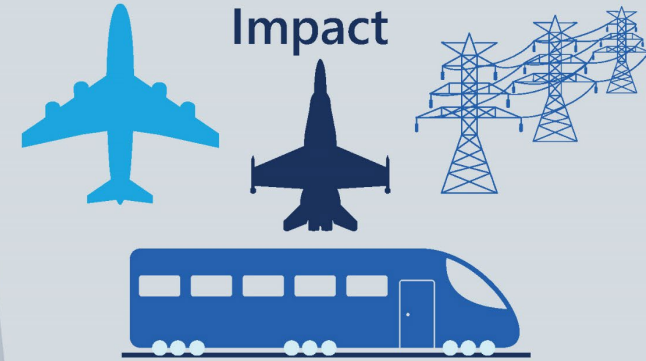
Energy-intensive technology that struggles to compete in the global marketplace

Demonstrations



State-of-the-art, energy-efficient smelter designed to run on 100% renewable energy

Real World Impact



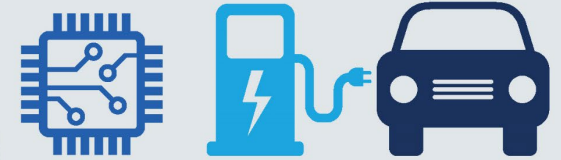
High-purity aluminum critical to defense, aerospace, electricity and transportation applications



Material landfilled or shipped overseas for recycling



U.S.-based recycling adds value for consumers



High-purity copper for semiconductors and electric vehicles



Fossil-fired heat needed for multiple process steps



Fuel switching and new processes improve efficiency and remove heating steps



Decarbonized aluminum for tech companies, beverages, and packaging

HEAT

3 GLASS |
3 FOOD & BEVERAGE |
2 PROCESS HEAT

8
projects

\$700M+
federal investment

1.5M
metric tons CO₂
avoided annually

Traditional Production



Heat is critical for many manufacturing processes –
and today most plants rely on fossil fuels

Demonstrations



Specialized decarbonized burners
Thermal batteries powered by renewables
Electrification approaches
including microgrids, electric boilers,
heat pumps, and more

Real World Impact



Decarbonized versions of products
Americans use every day





Note: Anticipated based on information provided to the Department of Energy as of March 2024



IDP Projects Substantially Address the Liftoff Opportunity Space

	Chemicals	Refining	Iron & Steel	Food & Beverage	Cement & Concrete	Pulp & Paper	Aluminum	Glass
Carbon capture, utilization, & storage	✓	✓			✓			
Industrial electrification	✓		✓	✓	✓		✓	✓
Energy efficiency	✓	✓	✓	✓	✓	✓	✓	✓
Electrolytic hydrogen	✓		✓					
Raw material substitutions	✓		✓		✓			✓
Alt. fuel (non-H2)				✓	✓		✓	✓
Alt. production methods	✓		✓		✓	✓	✓	

 Lever demonstrated in project(s)
 Lever not demonstrated in project(s)
 Blank represents limited relevance to sector decarbonization

visit liftoff.energy.gov

OCED Has Selected 20+ Projects Capturing CO₂

Selectees Include...

8 Carbon Capture Front-End Engineering and Design Studies

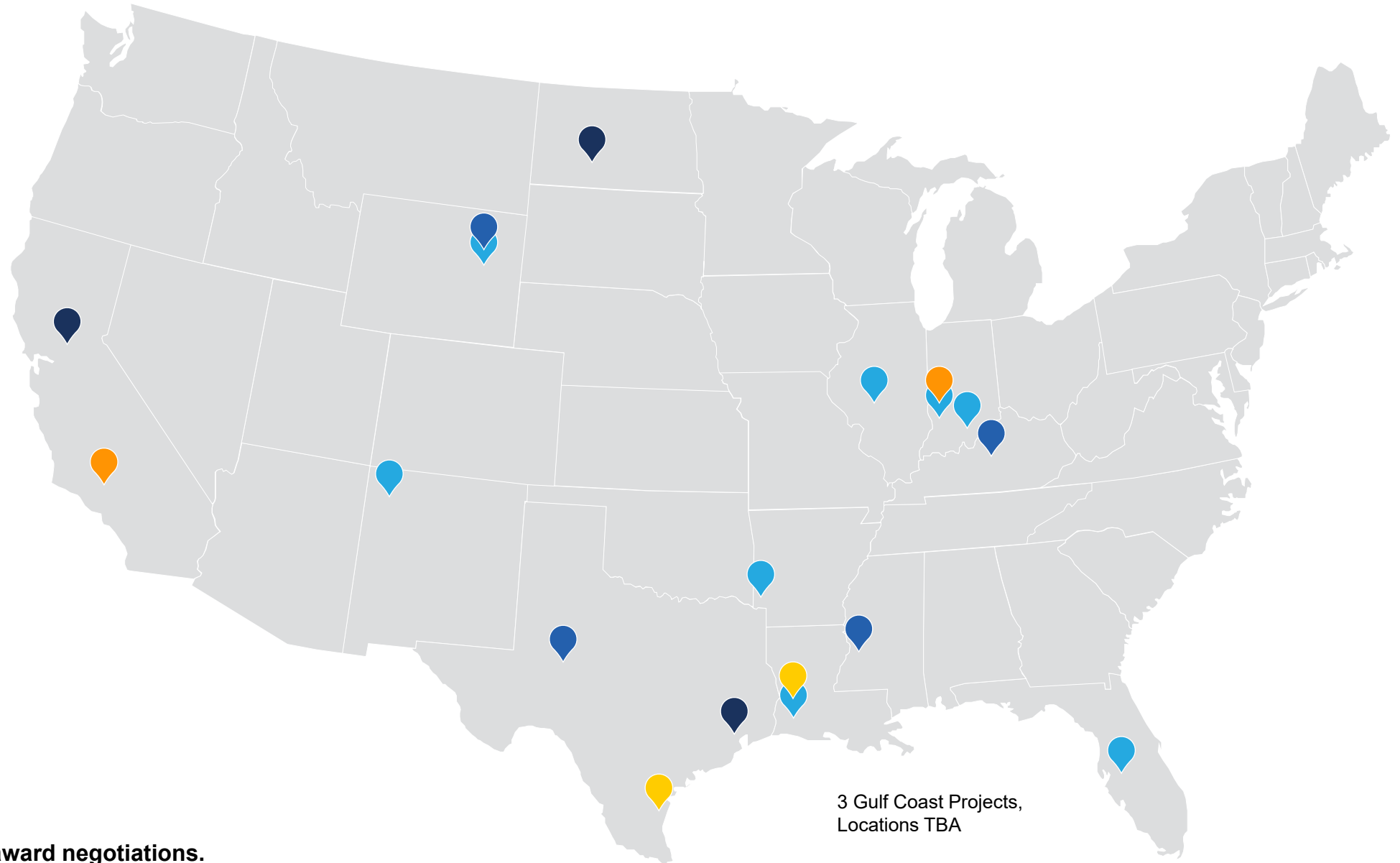
4 Carbon Capture Large-Scale Pilot Projects

3 Carbon Capture Demonstration Projects

5 Industrial Demonstration Projects

2 Direct Air Capture Hubs

6 Hydrogen Hubs
(not shown on map)



*Several projects are pending award negotiations.



For more information

- For questions regarding IDP projects email engage_industrialdemos@hq.doe.gov

- OCED Website & Newsletter Sign-up energy.gov/oced

Scroll to bottom to sign up here:

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- OCED Exchange (RFIs, NOIs, and FOAs) oced-exchange.energy.gov
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Thank you!



OCED
Office of Clean Energy Demonstrations

For more information, please visit energy.gov/OCED



Overview of Industrial Efficiency and Decarbonization Office

Celina Harris, Ph.D., *Technology Manager*
Industrial Efficiency and Decarbonization Office

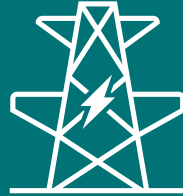
FECM/NETL Carbon Management Research Project Review Meeting
6 August 2024

DOE Industrial Decarbonization Roadmap

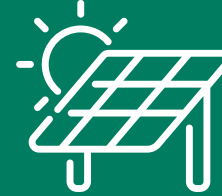
Industrial Decarbonization Pillars



Energy
Efficiency



Industrial
Electrification



Low-Carbon Fuels,
Feedstocks, and Energy
Sources (LCFFES)



Carbon Capture,
Utilization, and
Storage (CCUS)

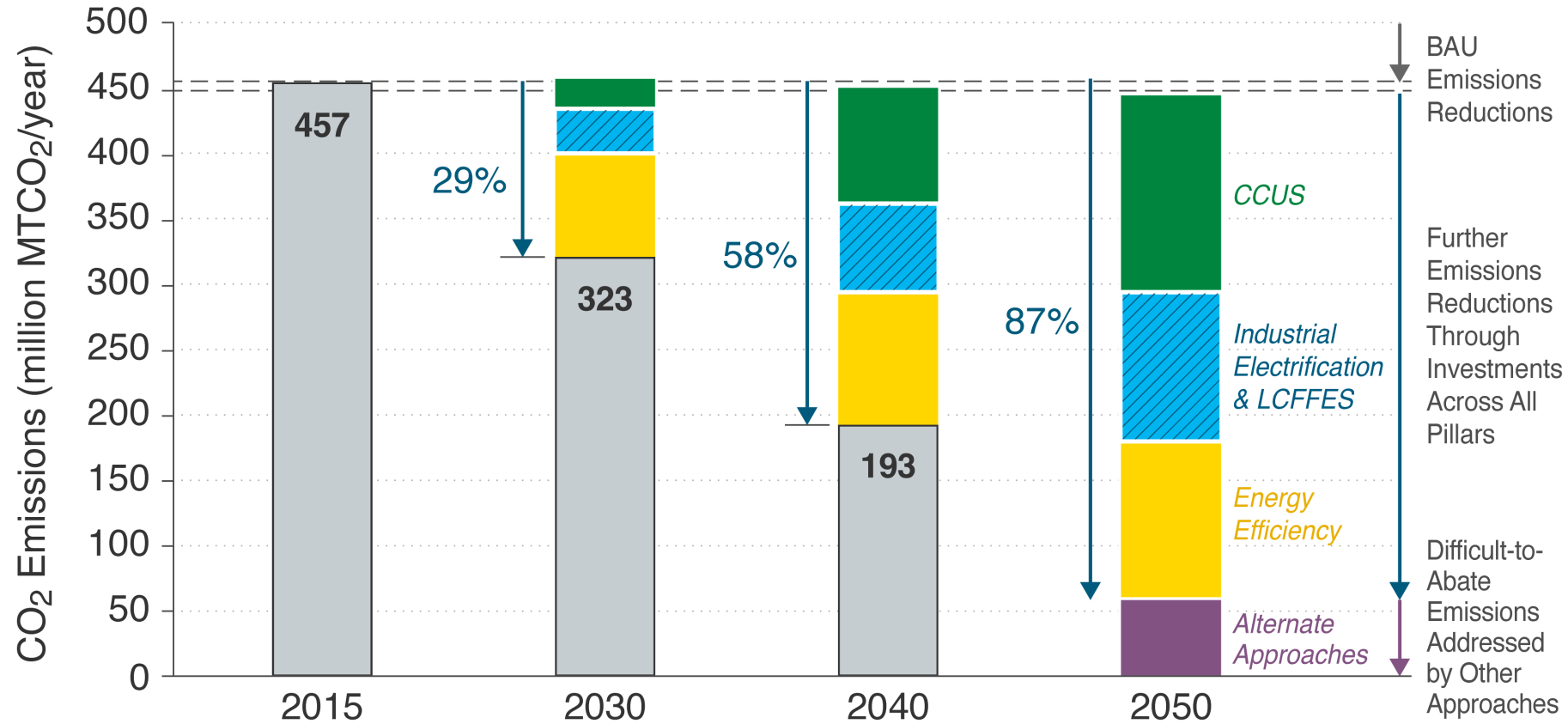
Decarbonization pillars: inter-related, cross-cutting strategies to pursue in parallel

- Invest in all pillars
- Leverage cross-sector approaches
- Interdependencies require systems solutions
- Strategies are needed to minimize implementation hurdles, address scale-up, and accelerate adoption



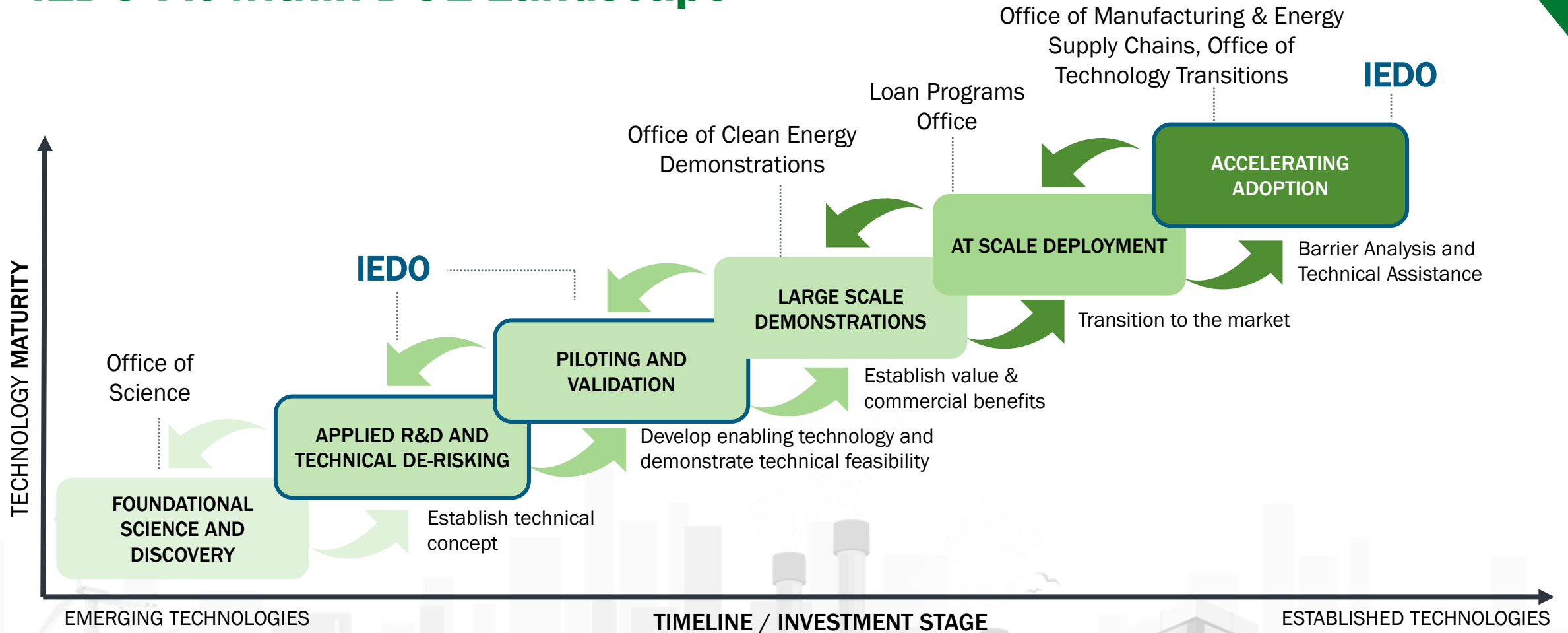
www.energy.gov/eere/doe-industrial-decarbonization-roadmap

Path to Net-Zero Emissions by 2050



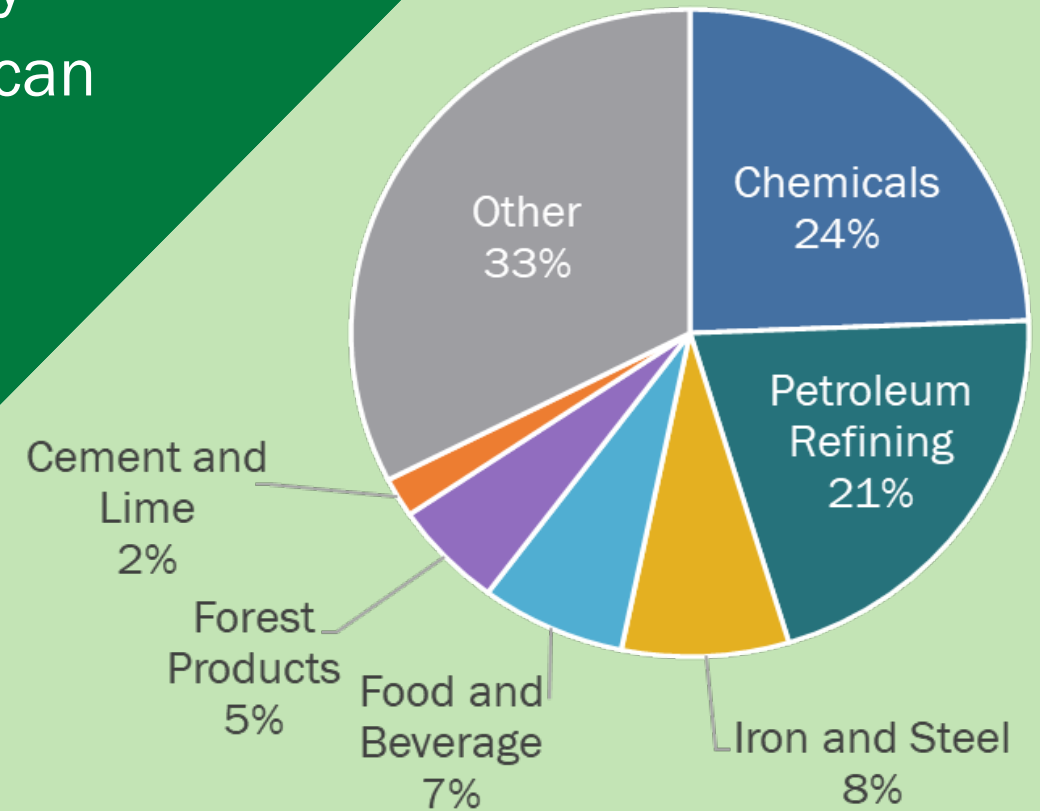
- Remaining GHG Emissions
- Emissions Reduction by CCUS
- Emissions Reduction by Industrial Electrification & LCFES
- Emissions Reduction by Energy Efficiency
- Emissions Reduction by Alternate Approaches (e.g., Negative Emissions Technologies)

IEDO Fit within DOE Landscape



IEDO's Research & Development Strategy

IEDO invests in both **sector-specific** technology solutions and **cross-cutting** technologies that can be applied across the industrial sector.



U.S. Manufacturing Energy-related CO₂ Emissions by Sector, 2020: 1124 MMT CO₂. Source: 2021 EIA AEO

Energy- and Emissions-Intensive Industries

IEDO accelerates the readiness of emerging, industry-specific technologies to decarbonize the most energy- and emissions-intensive industrial subsectors.



IRON AND STEEL

1,469 TBtu
100 MMT CO₂e



CHEMICALS

(including production of
low-carbon fuels)
4,842 Tbtu
332 MMT CO₂e



FOOD & BEVERAGE

1,935 TBtu
96 MMT CO₂e



FOREST PRODUCTS

2,883 TBtu
80 MMT CO₂e



CEMENT & CONCRETE

367 TBtu
66 MMT CO₂e

DOE [Manufacturing Energy and Carbon Footprint](#), based on EIA Manufacturing Energy Consumption Survey (MECS) data for 2018

Cross-Sector Technologies

The Cross-Sector Technologies subprogram accelerates the readiness of energy- and emissions-reducing components, systems, and operational technologies, across a broad range of industries.



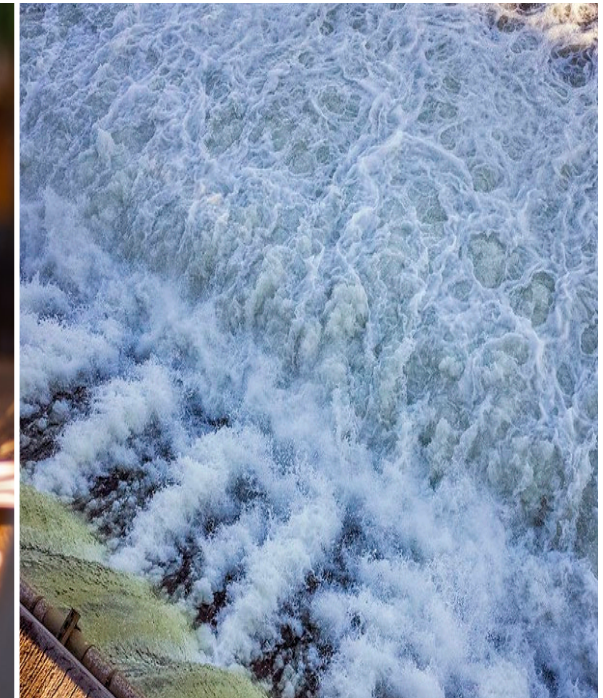
**Thermal Process
& Systems**



**Low-Carbon Fuels,
Feedstocks, & Energy Sources**



Emerging Efficiency



**Water & Wastewater
Treatment**

IEDO's Technical Assistance Efforts



**TA WORK PRODUCTS
INCLUDE:**

**ENERGY
ASSESSMENTS**

**PEER-TO-PEER
NETWORKING**

**TOOLS &
TRAINING**

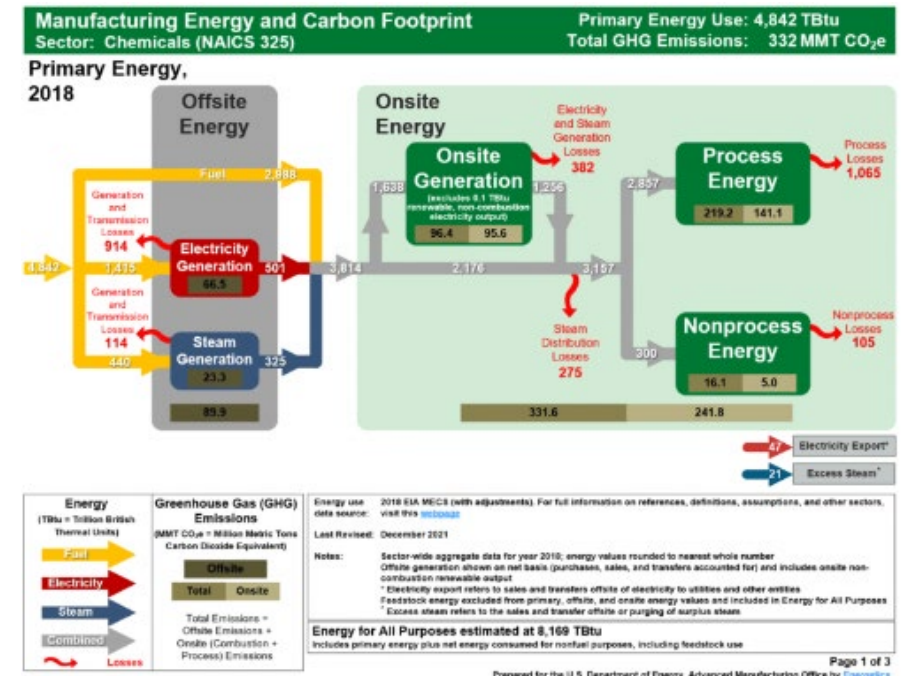
**TECHNOLOGY
SCREENING**

**PROJECT
PROFILES**

Strategic Analysis Tools & Resources

IEDO's manufacturing, materials, and lifecycle energy tools and resources use a cross-sector and prospective **life cycle assessment (LCA)** approach that anticipates future benefits and impacts.

- Environmentally Extended Input-output For Industrial Decarbonization Analysis (Eeio-ida) Tool
- Techno-economic Energy & Carbon Heuristic Tool For Early-state Technologies (Techtest) Tool
- Materials Flows Through Industry (Mfi) Tool
- Life Cycle Greenhouse Gas, Technology And Energy Through The Use Phase (Lightenup) Tool
- Plant Water Profiler Tool - Excel, Beta Version (Pwpex V0.1)
- Carbon Fiber Reinforced Plastic (Cfrp) Energy Estimator Tool
- Additive Manufacturing (Am) Energy Impacts Assessment Tool
- Manufacturing Energy and Carbon Footprints



<https://www.energy.gov/eere/iedo/energy-analysis-data-and-reports>

IEDO Funded Projects

FY22 Industrial Efficiency and Decarbonization:

- \$135M for 40 projects to decarbonize the five highest-emitting industrial subsectors

FY23 IEDO Multi-Topic:

- \$171M for 49 projects to advance high-impact applied RD&D projects to decarbonize the U.S. industrial sector. Includes sector-specific and cross-sector approaches.

Decarbonization of Water Resource Recovery Facilities:

- \$27.8M for 10 projects to decarbonize the entire life cycle of Water Resource Recovery Facilities



Electrified Processes for Industry Without Carbon (EPIXC)

- A 5 year, **\$70M** federal investment to fund RD&D projects to electrify process heating.
- Mobilize a **multisector coalition** of private companies, National Labs, universities, labor unions, and community partners to **create an innovation ecosystem**.
- Bridge the gap between research and commercialization to move **novel electrification processes** out of the lab and into the market.



Project Highlight: Integration of CO₂ Capture and Electrocatalytic Conversion to Organic Liquids

Project Lead: Northern Illinois University

Project Partners: Argonne National Laboratory; University of North Texas; Angstrom Advanced

Technology Transition:

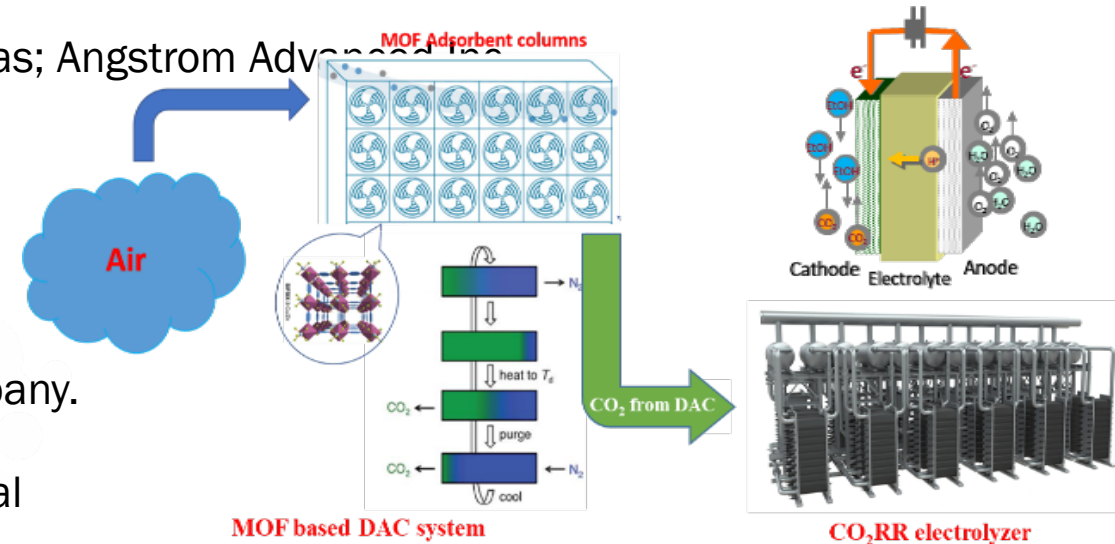
- The prototype of the integrated CO₂ capture and utilization device will be introduced to various industrial companies that either use or produce CO₂ at large scales.
- The team will seek opportunities for technology transfer of their CO₂-to-organic liquids electrocatalysts to a large catalysts company.

Innovation:

- Integrating direct CO₂ air capture with highly efficient electrochemical conversion of CO₂ to value-added organic liquids
- Superior metal organic framework (MOF) DAC adsorbents combined with state-of-the-art electrocatalysts

Project Impact:

- Dramatic improvements in CO₂-to-ethanol FE (>90% vs. 41% SOA) and current density (>200 mA/cm² vs. 124 mA/cm² SOA)
- Potential to produce ethanol with zero or negative emissions



Project Highlight: Integration of CO₂ Capture and Electrocatalytic Conversion to Organic Liquids

Project Lead: LanzaTech

Project Partners: Washington Mills, RAPID Manufacturing Institute

Technology Transition:

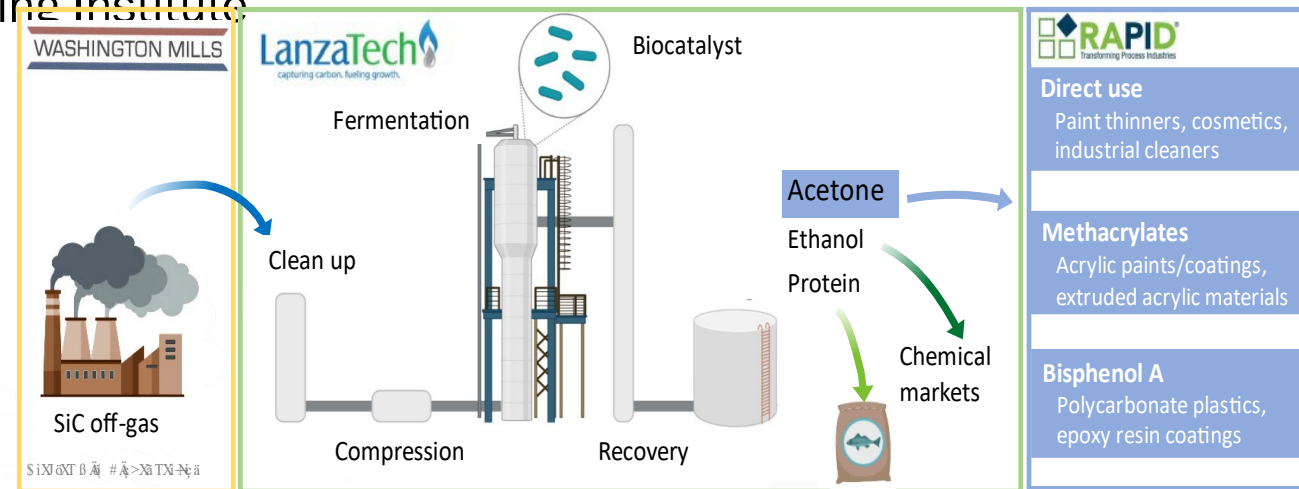
- LanzaTech is experienced at linking feedstock providers, chemical producers, industrial plant owners, investors, and manufacturing partners to develop demonstration and economically viable commercial projects.

Innovation:

- Production of acetone through a gas fermentation process using off-gas from ferro-silicon (SiC) manufacturing operations and a tailored bio-catalyst

Project Impact:

- Potential for negative lifecycle emissions: -1.8 kg CO₂/kg acetone
- Reduction of waste emissions while becoming part of the circular economy by co-generating a value-added product



In Review: Current EEl and CST Funding Opportunities

FY24 Cross-Sector Technologies FOA:

- **\$38M** to accelerate the innovative, cross-sector technologies required to decarbonize industry.

FY24 Energy- and Emissions-Intensive Industries

- **\$83M** to focus on applied RD&D for the highest GHG-emitting industrial subsectors, specifically: chemicals and fuels; iron and steel; food and beverage; building and infrastructure materials (including cement and concrete, asphalt pavements, and glass); and forest products.



In Review: Current EEl and CST Funding Opportunities

FY24 Energy- and Emissions-Intensive Industries

Topic Area 6 Industrial Preliminary Front-End

Engineering Design Studies (pre-FEED):

Collaboration with HFTO and FECM

Area of Interest 1: Integration of Clean Hydrogen in the Industrial Sector

Area of Interest 2: Carbon Capture for the Industrial Sector

Area of Interest 3: Integrated Processes Pre-Feed



IEDO IS HIRING

Help decarbonize the
U.S. industrial sector

U.S. DEPARTMENT OF
ENERGY

Office of ENERGY EFFICIENCY
& RENEWABLE ENERGY

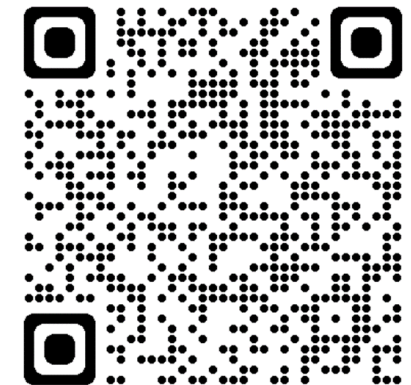
INDUSTRIAL EFFICIENCY & DECARBONIZATION OFFICE

Apply
Now!

Current IEDO Career Opportunities

- Cross-Sector Technologies Program Manager
- Senior Advisor on Industrial Markets

Email: IEDOJobs@ee.doe.gov



www.energy.gov/eere/iedo/iedo-careers

Fellowship Opportunity

Industrial Efficiency and Decarbonization Office

Apply Now!

Deadline August 15

Apply for IEDO's Industrial Decarbonization Fellowship to help identify key technology opportunities for the hardest-to-decarbonize industries.

As a fellow, you'll contribute to the development and execution of strategies for:

- Decarbonizing thermal processes,
- Increasing industrial energy efficiency, and
- Utilizing low-carbon fuels, feedstocks, and energy sources



Thank You!

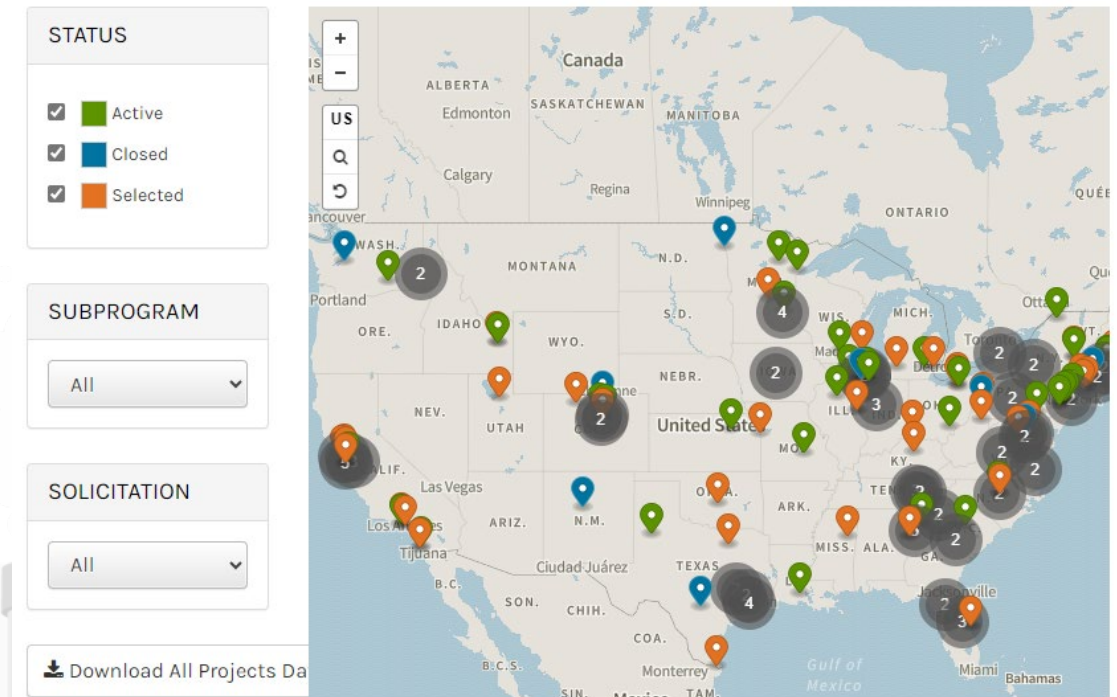
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IEDO Project Database



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