

Strategic Vision and Programmatic Update



U.S. DEPARTMENT OF
ENERGY

Fossil Energy and
Carbon Management

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Program Manager



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Mission

- Demonstrate and ultimately deploy carbon management technologies through multiple carbon conversion approaches
- Mitigate externalities of fossil fuel use in a just and sustainable way, with the goal of achieving net-zero greenhouse gas emissions by mid-century

Goals

- Economically transform CO₂ into products, in an environmentally conscious manner
- Integrated test systems to support higher TRL testing on representative CO₂ streams

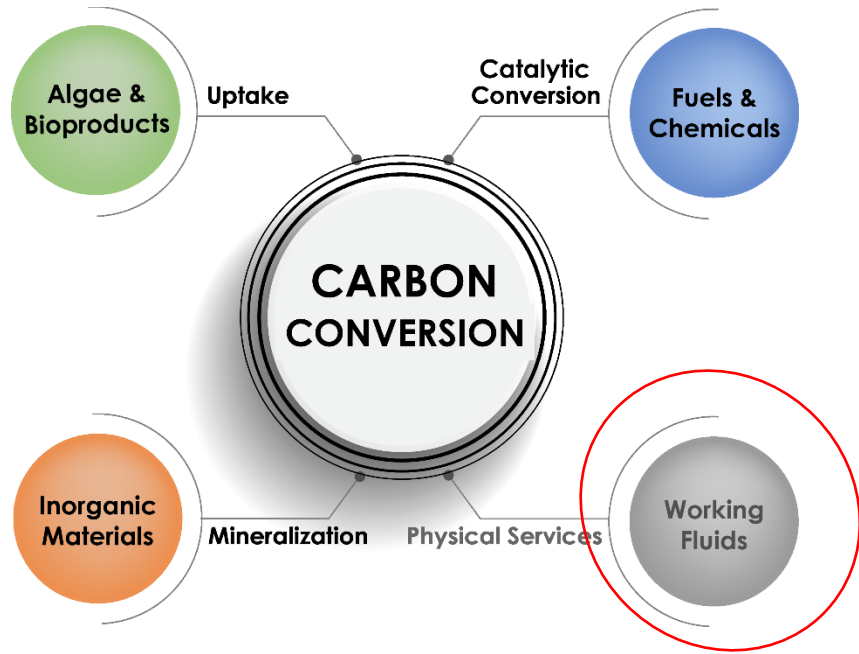
Drivers

- United States 2019 CO₂ energy related emissions ≈ 5.1 gigatonnes
 - Total global equivalent ≈ 33.1 gigatonnes

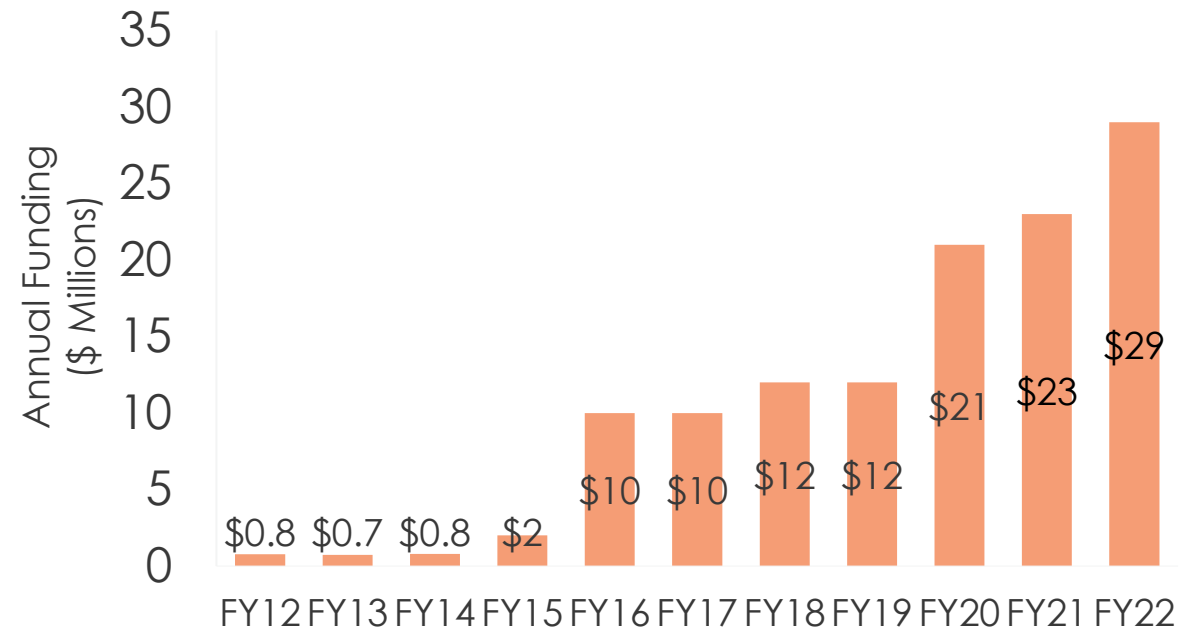
Challenges

- Scale of CO₂ emissions relative to CO₂ conversion
- Qualifying economic viability and environmental impact requires significant resources
 - Technical viability is relatively easy to qualify
- Availability and carbon footprint of energy inputs (e.g. electricity, hydrogen, etc...)
- “It’s tough to make predictions, especially about the future”

Carbon Conversion Program R&D



Focus of other programs



Over 40 projects within the portfolio across three conversion pathways

- Most are competitively awarded cooperative agreements (funded through FOAs)
- Some are awarded through grant programs (SBIR/STTR)
- Agreements with National Labs through Field Work Proposals
- Other mechanisms such as TCF, UTR, ACT

A variety of markets are addressed by these conversion products

- Concrete (including cement, aggregate, and curing)
- Polymers
- Fuels
- Chemicals
- Animal feed
- Solid carbon products

Program supported XPRIZE winning R&D of UCLA Carbon Built

- One of two winners out of forty-seven submissions from seven countries
- “This outstanding project represents another example of how the U.S. Department of Energy’s (DOE) Office of Fossil Energy and NETL collaborate with and support outstanding university researchers to advance carbon management solutions and reduce CO₂ emissions,” said NETL Director Brian Anderson, Ph.D.

Supporting R&D in new and existing areas

- Reactive Capture and Conversion (RCC)

Collaboration with multiple stakeholders

- Necessary due to the scale and breadth of the challenge
- Interest in carbon conversion has increased drastically within the last six months

Multiple funding possibilities this year

- FOA 2614 – Carbon Management (currently open)
- FOA 2654 – Carbon Utilization Technology: Improving Efficient Systems for Algae
- SBIRs

Enabling Technologies and Facilities



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National Energy Technology Laboratory (NETL)



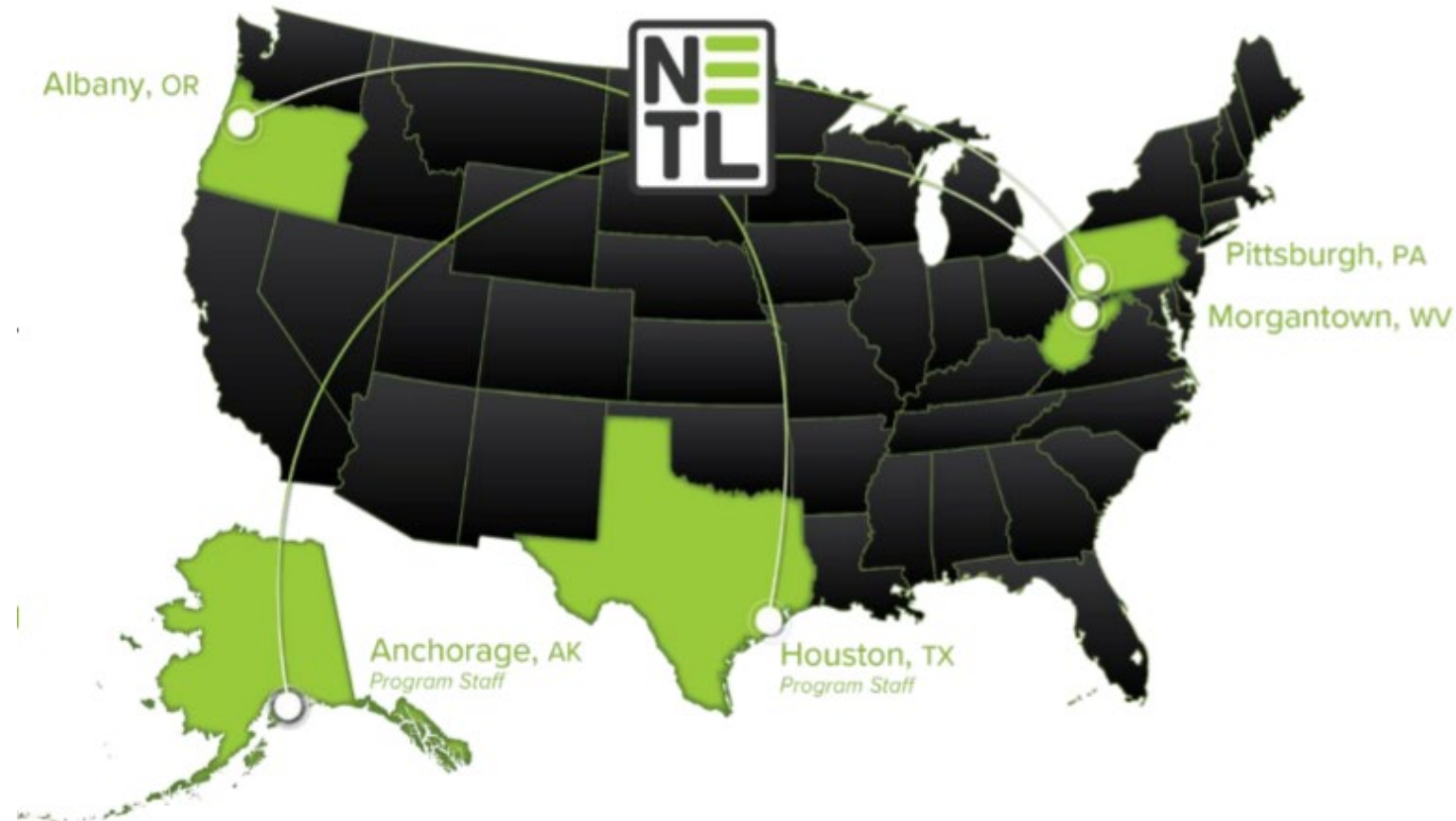
One of 17 U.S. Department of Energy (DOE) national laboratories; producing technological solutions to America's energy challenges.

NETL Mission

- Ensuring affordable, abundant and reliable energy that drives a robust economy and national security, while
- Developing technologies to manage carbon across the full life cycle, and
- Enabling environmental sustainability for all Americans.

NETL Vision

To be the nation's premier energy technology laboratory, delivering integrated solutions to enable transformation to a sustainable energy future.



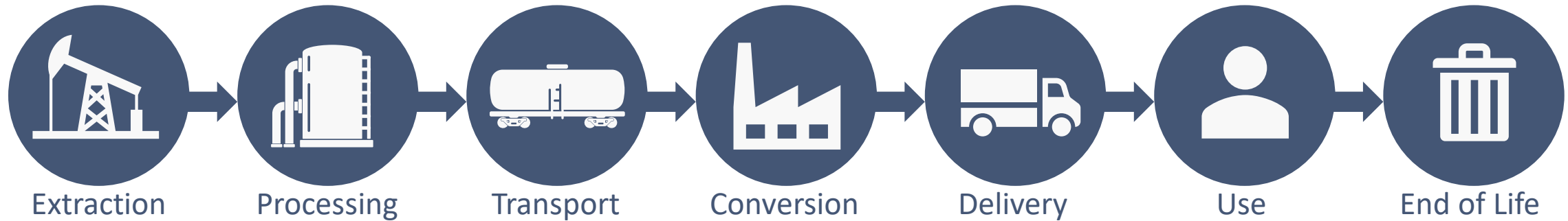
Life Cycle Analysis through Energy Systems Analysis Team

- Vital to determining economic viability and environmental impact
- Active in International CCU Assessment Harmonization Group
- Challenges
 - Working to harmonize LCA methodology with other groups
 - Requires collaboration across multiple offices, departments, and external entities

Techno-Economic Analysis through Energy Process Analysis Team

- All successful technologies must add value
- Sensitivity analysis dependent upon many unknowns
- Challenges
 - Not as straightforward to qualify as technical viability

What is Life Cycle Assessment (LCA)?



LCA is a technique that helps people make better decisions to improve and protect the environment by accounting for the potential impacts from raw material acquisition through production, use, end-of-life treatment, recycling, and final disposal (i.e., cradle-to-grave).

Necessity of TEA/LCA for an Uncertain Future

Tomorrow will look a lot like today

- Mix of fossil, renewable, and nuclear resources
 - Abundant waste heat integration opportunities
- Industrial electricity prices of \$60 - \$80 / MWh

Inexpensive and Abundant Hydrogen

- \$1/kg Hydrogen
 - Thermochemical conversion of CO₂ into chemicals and plastics
 - Industry widely decarbonized (e.g. steel, cement, fertilizer)

Techno-Cornucopian worldview

- Inexpensive electricity at \$20 - \$30 / MWh
- Widescale electrification
- Favorable for electrochemical approaches

Other Unknowns

- Carbon prices/credits, DAC costs, energy breakthroughs, etc...

IIJA FECM Sec 40302 Overview

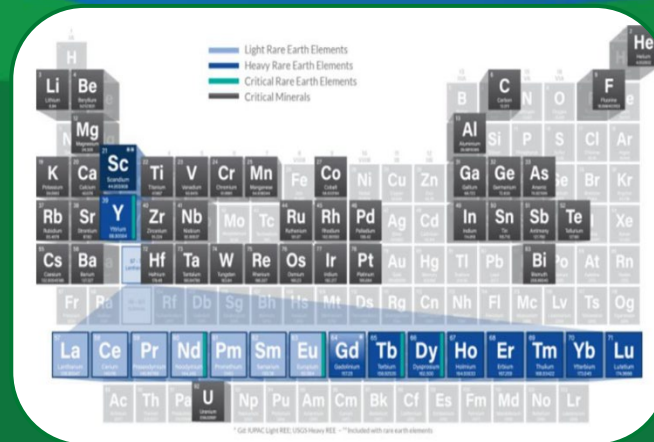


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SEC. 40302

Directs the Secretary to establish a program for **eligible entities** ...to submitan application.... An eligible entity shall use a grant received to **procure and use commercial or industrial products** that

- (i) use or are derived from *anthropogenic carbon oxides*; and
- (ii) demonstrate significant net reductions in *lifecycle greenhouse gas emissions compared to incumbent technologies, processes, and products*.

<https://uscode.house.gov/view.xhtml?hl=false&edition=prelim&req=granuleid%3AUSC-prelim-title42-section16298a&f=treesort&num=0>

Critical Points

- “(1) \$41,000,000 for fiscal year 2022;
- “(2) \$65,250,000 for fiscal year 2023;
- “(3) \$66,562,500 for fiscal year 2024;
- “(4) \$67,940,625 for fiscal year 2025; and
- “(5) \$69,387,656 for fiscal year 2026.”.

- DOE total funding for *demonstration* Procurement Grant program is flexible
- Procurements grants will go to eligible entities
 - State government
 - Local government
 - Public utilities
- Net reduction in life cycle GHG emissions

DOE/NETL CO2U LCA Guidance Toolkit

- CO2 utilization LCA guidance and tool package for Carbon Utilization Program primary research projects
- LCA guidance, open source LCA software (openLCA), NETL data, and results reporting tools
- An openLCA database has been populated with data and an example to help conduct LCA within the openLCA software
- An Excel tool has been created to take openLCA results and translate them into stacked bar charts for results communication

 <p>CO2U LCA GUIDANCE DOCUMENT FOR THE U.S. DOE OFFICE OF FECM, VERSION 2.0</p> <p>Analysis requirements and instructions for using the supporting data and tools</p>	 <p>NETL CO2U LCA DOCUMENTATION SPREADSHEET</p> <p>Excel file that can be used to document data when not using openLCA</p>	 <p>TRAINING RESOURCES</p> <p>Provided to funding recipients to aid in modeling an LCA</p>
 <p>NETL CO2U OPENLCA LCI DATABASE VERSION 2</p> <p>openLCA database that includes NETL unit process data and an example CO2U LCA</p>		<p>45Q ADDENDUM AND TOOLS</p> <p>Information pertaining to the use of this toolkit in performing life cycle analyses in support of the 26 CFR § 1.45Q tax credit, including an addendum to the Guidance Document.</p>
 <p>OPENLCA CONTRIBUTION TOOL</p> <p>Excel template that translates openLCA results into required charts</p>	 <p>NETL CO2U LCA REPORT TEMPLATE</p> <p>Word report template for summarizing data and results</p>	<p>NETL ADDITIONAL DOWNLOADS</p> <p> Download Full Toolkit</p> <p> Patches, Archives, and Version History</p>

Toolkit available at netl.doe.gov/LCA/CO2U

Preliminary LCA Process for Procurement Grant Program



Product manufacturer completes LCA for eligible product(s) in accordance with guidelines and submits for review



DOE reviews manufacturer LCA:

- Conformance with guidelines
- Minimum of 10% improvement over business-as-usual



Once approved, manufacturer and product are added to an approved list of vendors

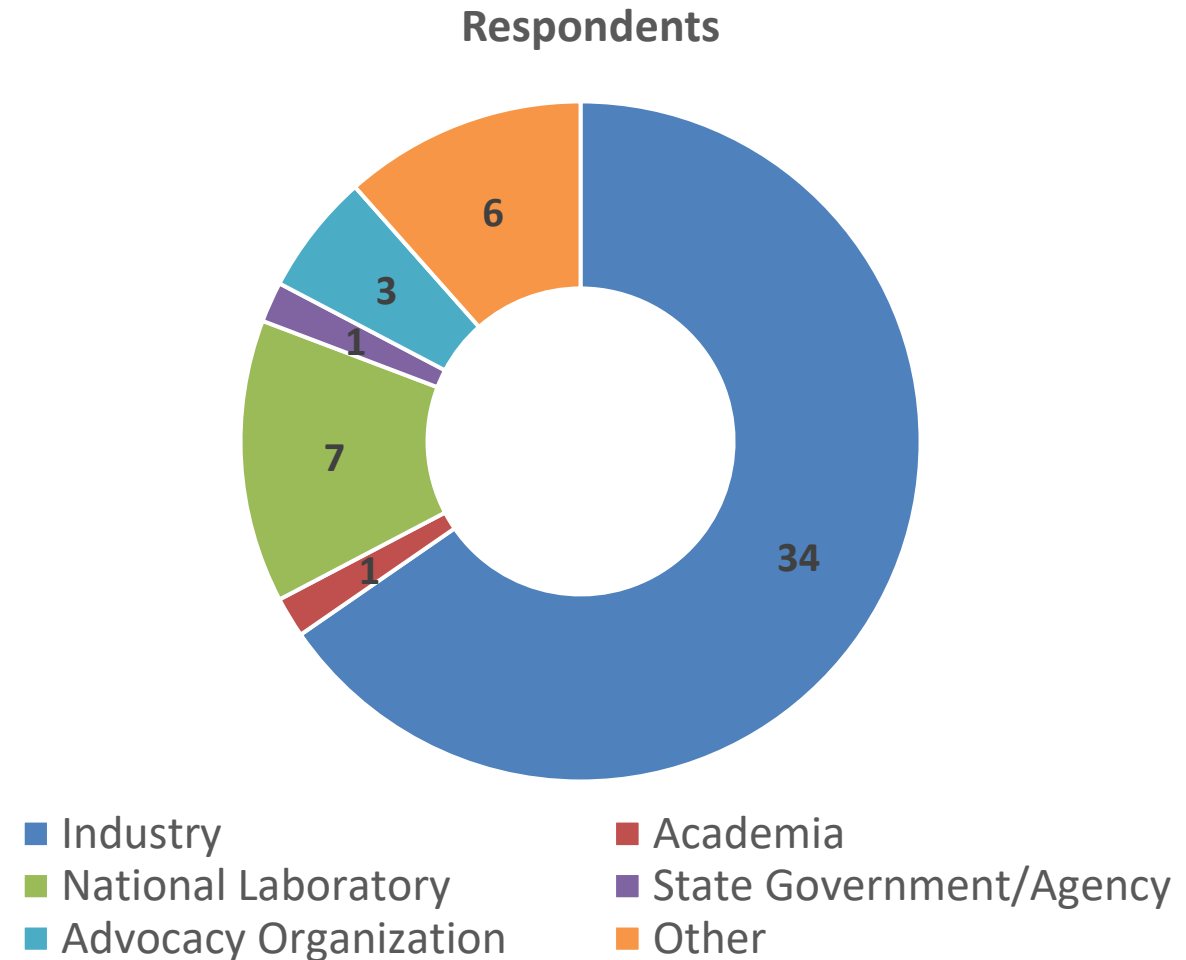


Eligible entities engage approved suppliers and establish a purchase agreement

RFI Technical Area #6 - Deployment and Demonstration Opportunities for Carbon Reduction and Removal Technologies

Response overview (52 total respondents)

- Industry (34)
- Academia (1)
- National Laboratory (7)
- State Government/Agency (1)
- Advocacy Organization (3)
- Other (6)
 - Includes non-profits, consultant, foundation, initiative, institutes



RFI Technical Area #6 Overall Summary

Funding, business models, and market considerations

- The current market offers a non-attractive business case due to high-cost premiums compared to fossil-derived materials.
- Several respondents expressed uncertainty on if or when 45Q applied to CO₂ conversion and this results in investment hesitation. Updated 45Q credit and/or other funding and incentives must be implemented to promote and, in some cases, sustain the commercialization of CO₂ conversion technologies/products.

Engagement and Existing Government Procurement Mechanisms

- Respondents most often specified that DOE should engage stakeholders at the state level, but responses varied from the Federal level all the way down to customers. The most common response is to engage commercially motivated stakeholders (i.e., industries) as well as government groups and agencies at all levels.

Product Codes, Standards and Certifications

- There is no current standard practice to measure, quantify, or report the carbon footprint of a product or technology. There is no verification that a product utilizes CO₂. There is no sufficiently detailed, standard method to perform life-cycle-analysis for CO₂ conversion.
- These issues must be remedied in order to allow for technology/product developers to obtain/qualify for some “low-carbon” certification (and possible subsequent incentive) and to encourage consumers to purchase such certified products. This will promote commercialization.

Technology

- Responses covered a wide variety of CO₂ conversion products and pathways.
- The discussed CO₂ utilization technologies spanned a range of maturity levels, but most technologies are at a lower TRL.
- Respondents commonly expressed the need for both standards and certifications as well as funding, incentives, and policy to support scale-up and commercialization efforts.
- The respondents claimed that CO₂ conversion would reduce CO₂ emissions. Details were scant for the market scale/emissions reduction potential of individual technologies and products, but several reports were cited that indicated that the CO₂ conversion market would see expansive growth and use up to several gigatons of CO₂ per year.
- Major commercialization is expected to commence in the early to mid 2030’s.
- Economic support to Underserved Communities, due to CO₂ conversion commercialization, would be provided due to the creation of new jobs ranging from construction, to product manufacture, to product value chains.

Additional References

- <https://usea.org/event/virtual-carbon-management-applicant-education-workshop>
- LCA Toolkit available at netl.doe.gov/LCA/CO2U



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