

Carbon Conversion Program USEA Presentation – 11/09/2023



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National Energy Technology Laboratory (NETL)



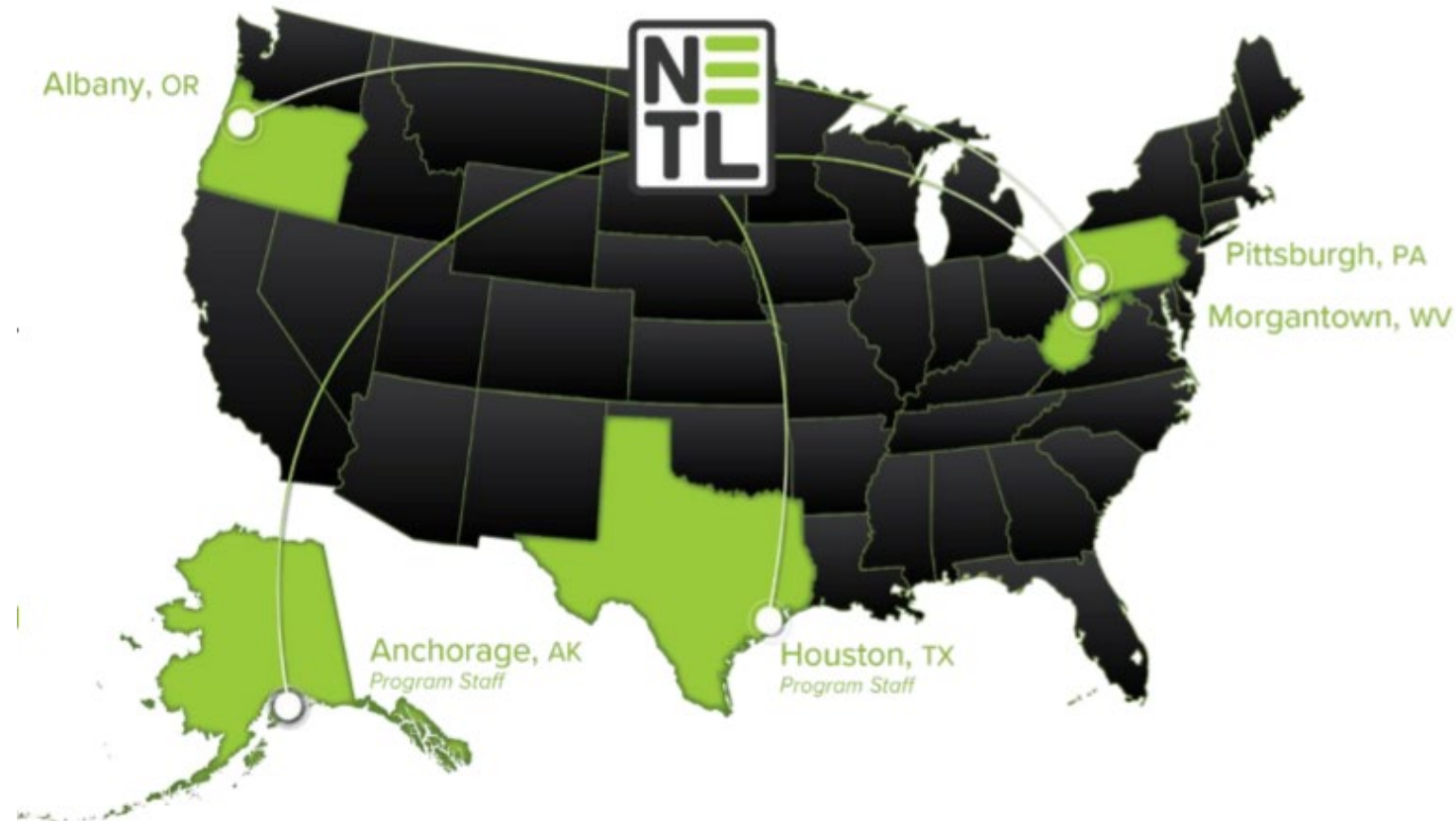
One of 17 U.S. Department of Energy (DOE) national laboratories; producing technological solutions to America's energy challenges.

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.

Vision

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



Strategic Vision and Programmatic Update



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 50% reduction in U.S. GHG pollution by 2030 and a carbon-neutral economy by 2050.

Goals

- Support R&D that can convert CO₂ into products
 - Conversion must be environmentally and economically attractive
- Support scaling (demonstration) of technology where appropriate

Drivers

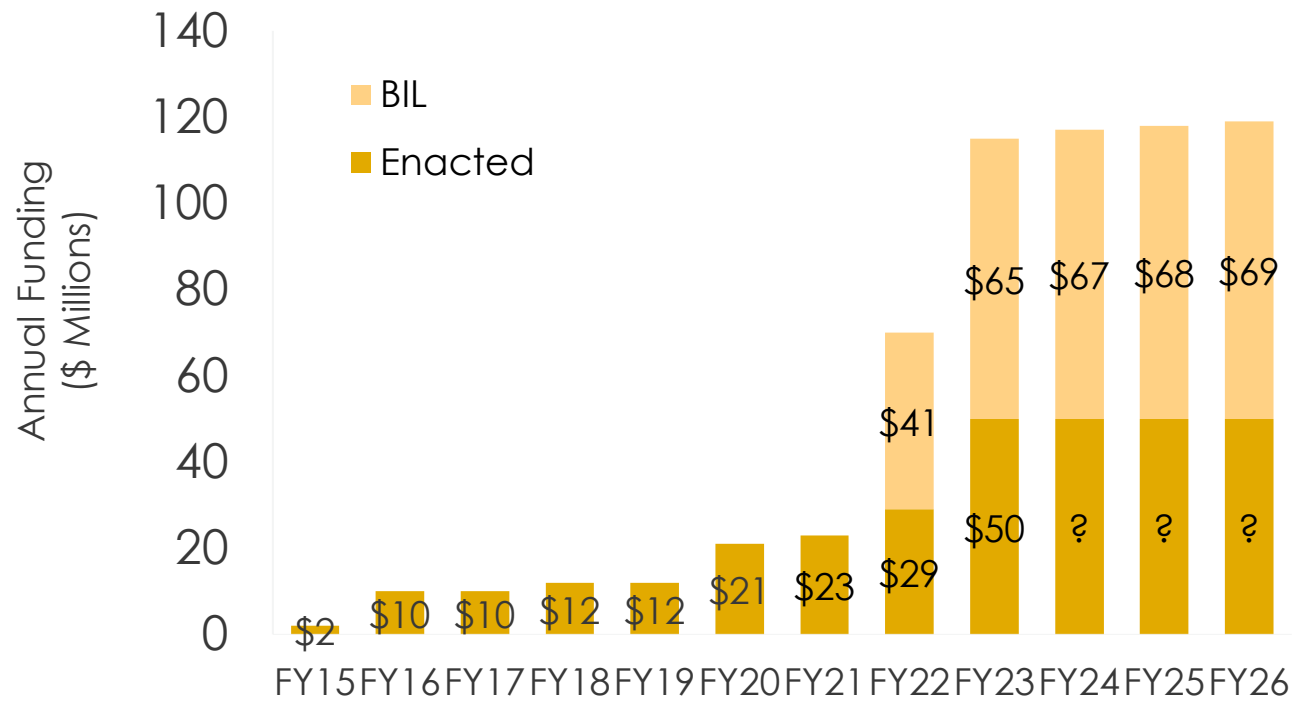
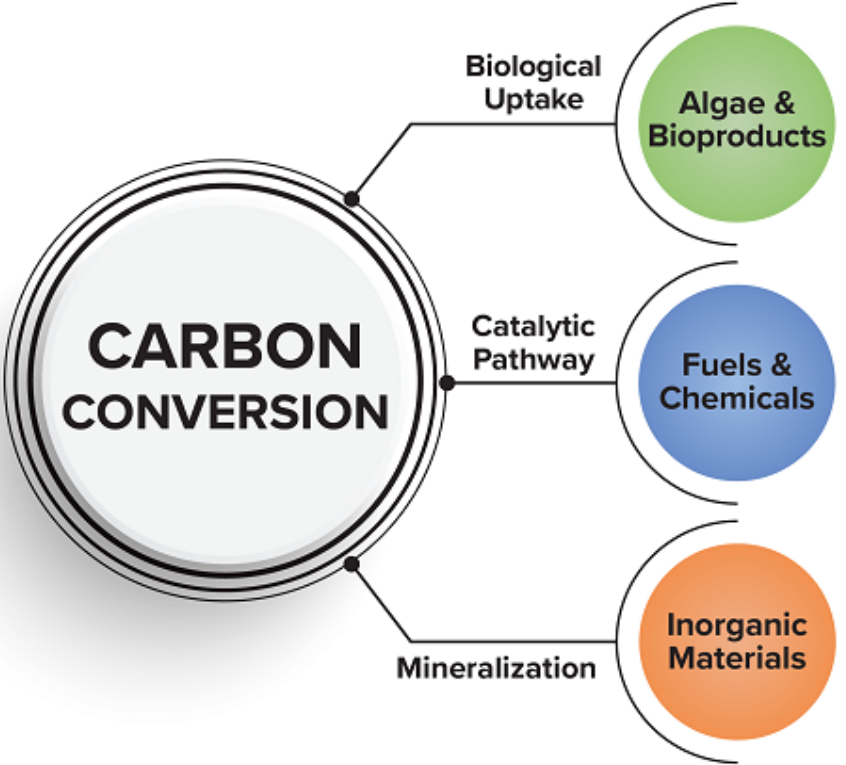
- United States 2022 CO₂ energy related emissions ≈ 5.0 gigatonnes
 - Total global equivalent ≈ 36.8 gigatonnes

Challenges

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

Program Structure and Budget

Carbon Conversion Program R&D Areas



R&D through Research and Innovation Center

- Majority focus on conversion into chemicals
- Activity in catalyst design, microwave reformation, reactive capture, and more

Life cycle Analysis through Energy Systems Analysis Team

- Vital to determining economic viability and environmental impact
- Active in Global CO₂ initiative
- 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
- Not as straightforward to qualify as technical viability

Carbon Conversion Through NETL via BIL



BIL represents ~\$310MM investment over five years

One aspect is “Utilization Procurement Grants,” aka UPGrants

<https://netl.doe.gov/upgrants>

DE-FOA-0002829

Demonstration Grants

50% cost share

To Eligible Entities

States, local gov, public utility/agency

Procure and use commercial or industrial products

Derived from anthropogenic carbon oxides

Less GHG emissions than incumbent

Vendor must pass critical review

UTILIZATION PROCUREMENT GRANTS (UPGRANTS)

As the U.S. economy moves toward clean energy and a lower carbon future, the U.S. Department of Energy (DOE) is seeking to partner with states, local governments, and public utilities and agencies to support the procurement and use of commercial or industrial products derived from anthropogenic carbon oxides. These efforts are enabled by provisions included in the Bipartisan Infrastructure Law (BIL) Section 40302. As part of the BIL, DOE's Office of Fossil Energy and Carbon Management (FECM) and NETL, through the Carbon Conversion Program, will establish a demonstration grant program for eligible entities to procure and use carbon conversion products. A notice of intent concerning this opportunity can be found [here](#)

Eligible Entities

- States
- Local Governments
- Public Utilities/Agencies

Eligible entities are defined as states, units of local governments, or public utilities and agencies. Eligible entities can learn more about the Utilization Procurement Grants (UPGrants) Program by visiting the [Eligible Entities information page](#). Additional supporting information can be found by visiting the [UPGrants Resources page](#).

Extramural research outside of NETL

Various funding mechanisms employed

- Field Work Proposals with other national laboratories
- Funding Opportunity Announcements
 - Majority of funding is competitively awarded
- Grant Programs
 - SBIR and STTR for small businesses and institutions of higher education
- Other mechanisms including TCF, ACT, EPSCoR

Robust project portfolio

- Thirty-five active projects within the portfolio and growing quickly
 - Mineralization, catalytic pathway, and biological uptake

A range of products are possible

- Animal feeds
- Nutraceuticals
- Dyes/colorants
- Polymers
- Soil amendments
- Fuels
 - Specific to the mission of DOE EERE's BETO (BioEnergy Technologies Office)

Advantages and challenges

- Uses well understood processes (10,000+ years of human agricultural experience)
- Mostly enabled with catalog engineering (uses COTS equipment)
- Biological processes well suited to creating many complex carbon molecules
- Large areas required to achieve gigatonne scale
 - Kinetically slower than higher temp/pressure processes

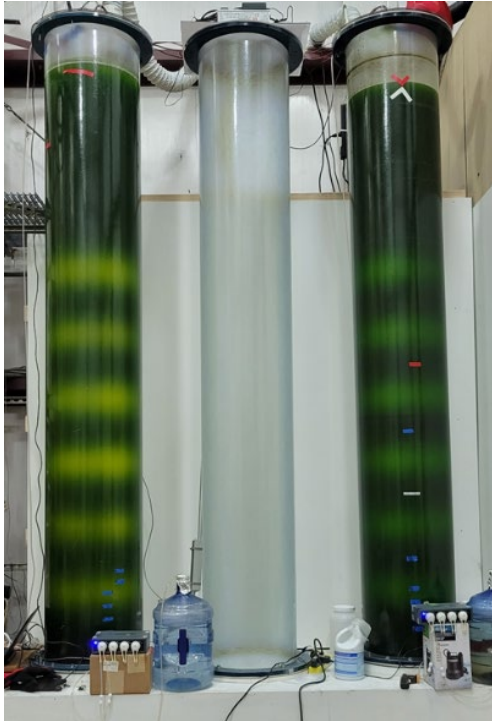
Carbon Conversion via Biological Uptake



Pictures courtesy of University of Illinois Urbana-Champaign



Picture courtesy of Global Algae Innovations



Picture courtesy of University of Maryland Center for Environmental Science

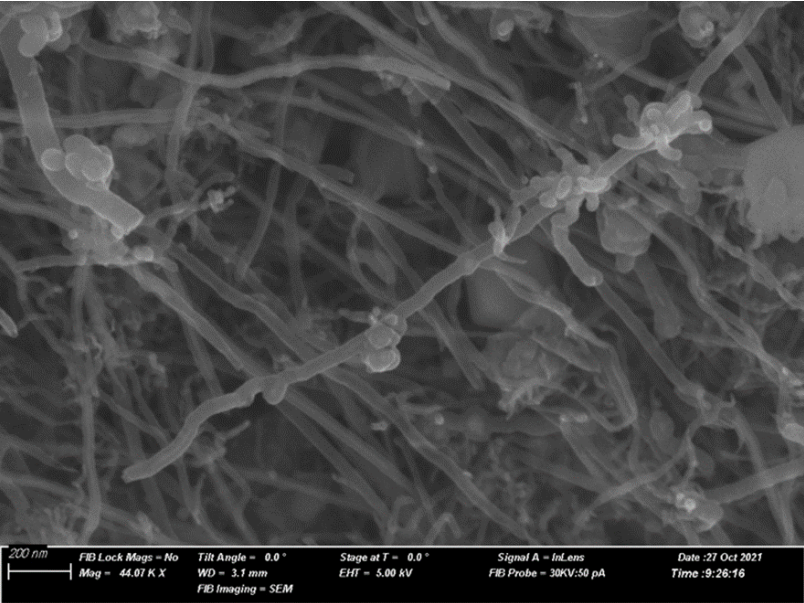
A wide range of products are possible

- Fuels
- Polymers
- Solid carbons
- Alcohols
- C2-C4 products (ethane, propane, butane, etc...)
- Methanol and Methane

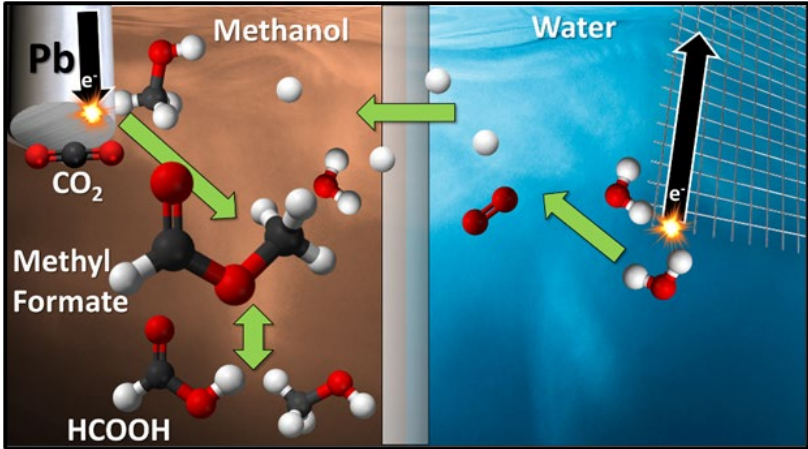
Advantages and challenges

- Pathways to gigatonne scale exist
- Almost any molecule can be synthesized
 - Including those currently derived from fossil fuels
- Value of products must outweigh cost of energy inputs
- Breakthroughs may require significant funding (e.g. electrochemistry and catalysts)

Carbon Conversion via Catalytic Pathway



Picture courtesy of SkyNano



Picture courtesy of University of Louisville

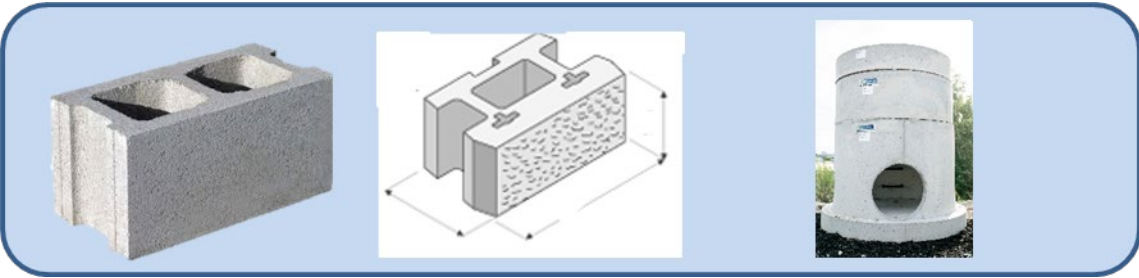
A limited range of products are possible

- Cured concrete blocks (CMUs)
- Synthetic aggregates
- Suboxides
- Other building materials

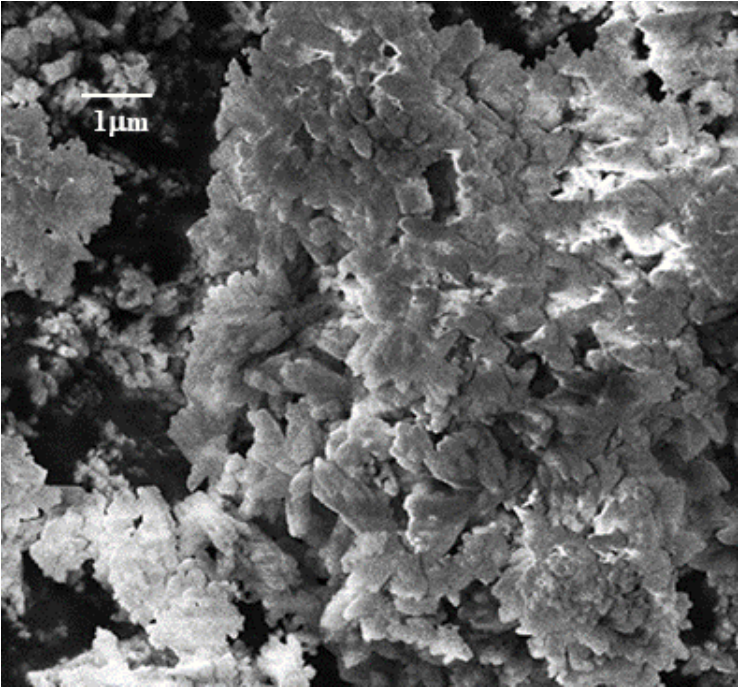
Advantages and challenges

- Can be energetically downhill
- Can apply at gigatonne scale
- Mostly enabled with catalog engineering (uses COTS equipment)
- Can address other waste streams (e.g. produced water or mine tailings)
- Products often have a low specific value (i.e. \$/tonne requires large scale)

Carbon Conversion via Mineralization



Pictures courtesy of UCLA



Picture courtesy of University of Wisconsin Madison

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, R&D costs, etc...

Carbon Conversion Program Tools



<https://netl.doe.gov/carbon-management/carbon-conversion>

NETL CO2U LCA GUIDANCE TOOLKIT

<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 2.1</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 § 1.450 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>

<https://www.netl.doe.gov/LCA/CO2U>

**Carbon Utilization
Interactive Project Map**

© 2022 Mapbox ©OpenStreetMap

For More Project Information: **CLICK** a location icon, then Click the **More Information** hyperlink to open the project landing page.

Technology Area

(All)

Technology Area

Carbon Uptake using Algae	8
Conversion into Fuels and Chemicals	22
Mineralization into Inorganic Materials	4

Project Count

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<https://netl.doe.gov/carbon-management/carbon-conversion>