

# Carbon Conversion Program Overview



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# National Energy Technology Laboratory (NETL)



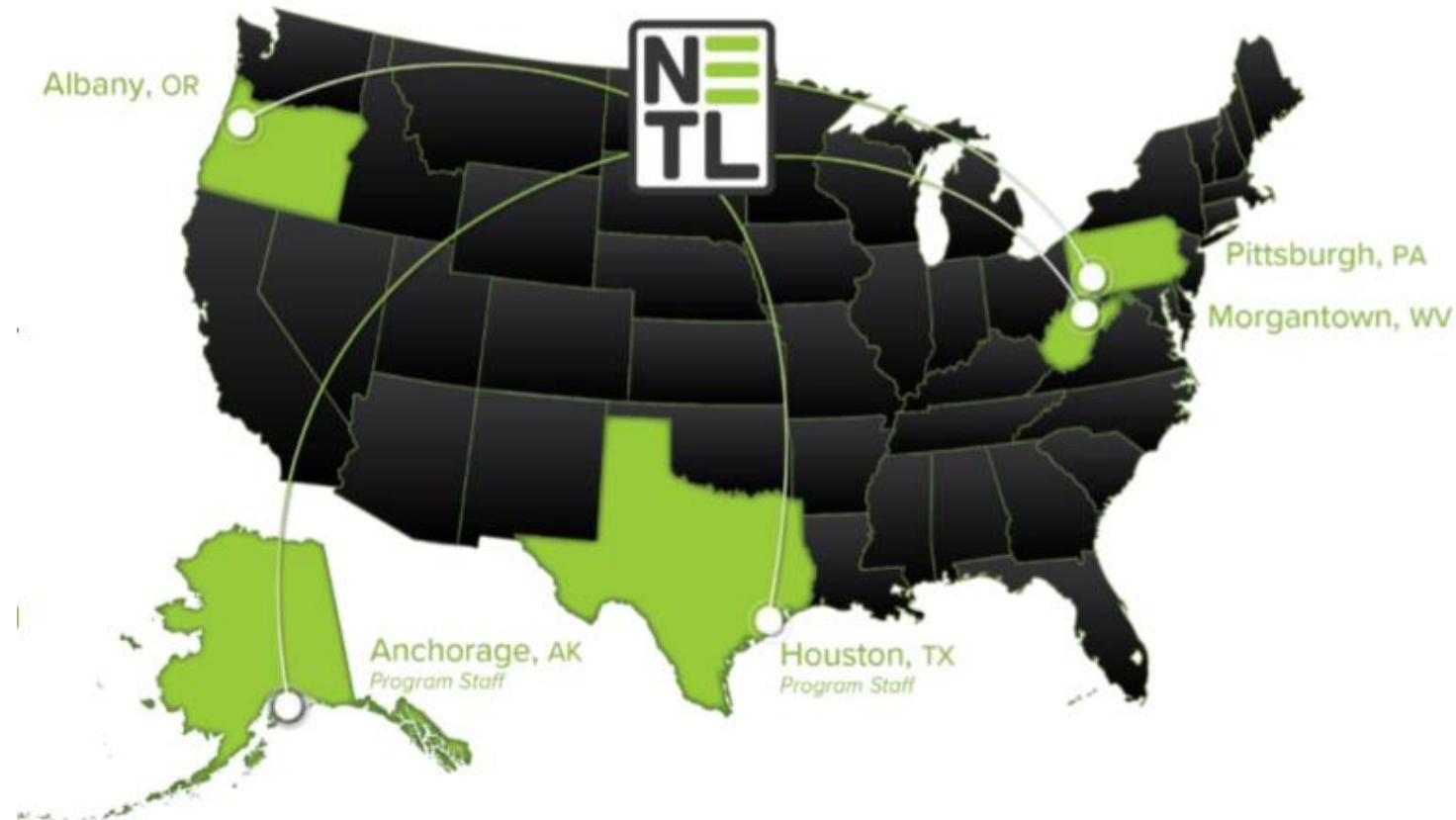
One of 17 U.S. Department of Energy (DOE) national laboratories; producing technological solutions to America's energy challenges.

## 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.



## Mission

- Advance carbon management through carbon dioxide conversion

## Goals

- Support R&D that can convert CO<sub>2</sub> into products
  - Conversion must be environmentally and economically attractive
- Support scaling (demonstration) of technology where appropriate

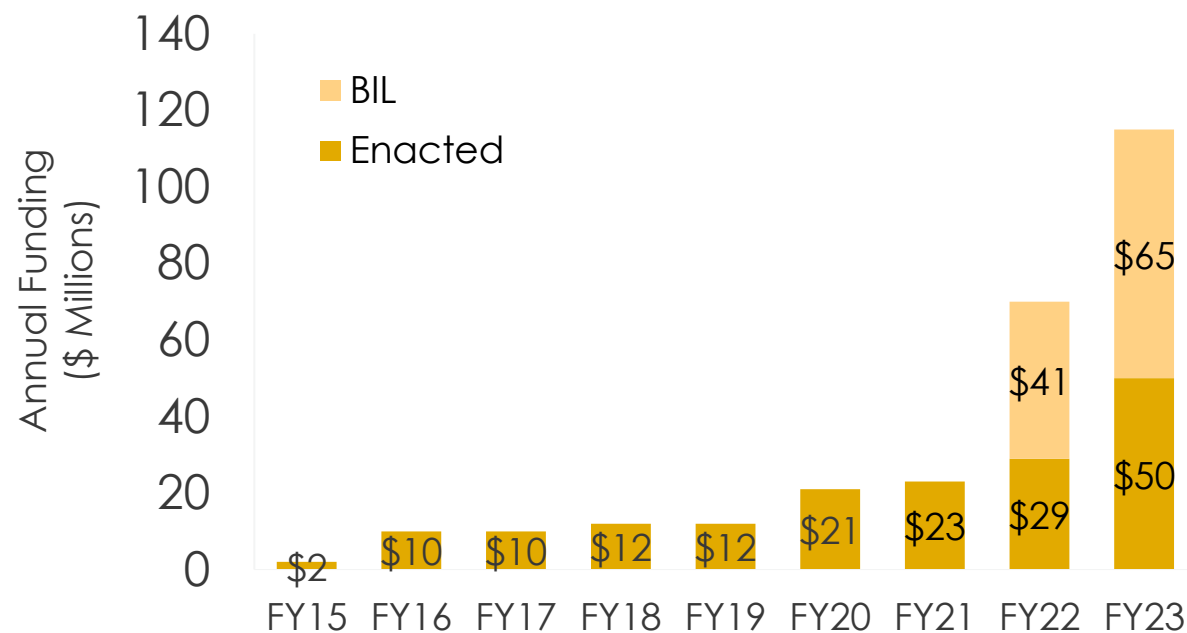
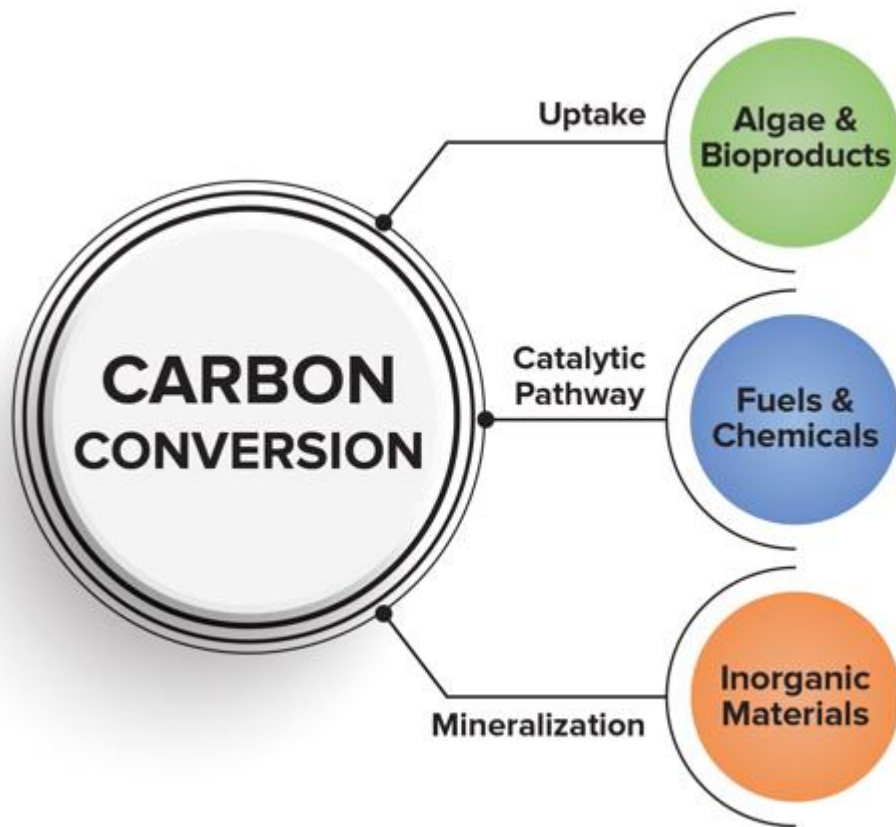
## Drivers

- United States 2020 CO<sub>2</sub> emissions ≈ 4.7 gigatonnes
  - Total global CO<sub>2</sub> emissions in 2021 ≈ 36.3 gigatonnes

## Challenges

- Scale of CO<sub>2</sub> emissions relative to CO<sub>2</sub> consumption
- Qualifying economic viability and environmental impact requires significant resources
- Electricity prices rarely negative/free
- “Prototypes are easy, production is hard”

## 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 CO<sub>2</sub> 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

## 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

**BIL represents ~\$310MM investment over five year**

**One aspect is “Utilization Procurement Grants,” aka UPGrants**

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

**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](#).




# Carbon Conversion Program Tools




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


## NETL CO2U LCA GUIDANCE TOOLKIT

 <p><b>CO2U LCA GUIDANCE DOCUMENT FOR THE U.S. DOE OFFICE OF FEGM, VERSION 2.0</b></p> <p>Analysis requirements and instructions for using the supporting data and tools</p>	 <p><b>NETL CO2U LCA DOCUMENTATION SPREADSHEET</b></p> <p>Excel file that can be used to document data when not using openLCA</p>	 <p><b>TRAINING RESOURCES</b></p> <p>Provided to funding recipients to aid in modeling an LCA</p>	
 <p><b>NETL CO2U OPENLCA LCI DATABASE VERSION 2.1</b></p> <p>openLCA database that includes NETL unit process data and an example CO2U LCA</p>		<p><b>45Q ADDENDUM AND TOOLS</b></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><b>OPENLCA CONTRIBUTION TOOL</b></p> <p>Excel template that translates openLCA results into required charts</p>		 <p><b>NETL CO2U LCA REPORT TEMPLATE</b></p> <p>Word report template for summarizing data and results</p>	<p><b>NETL ADDITIONAL DOWNLOADS</b></p> <p><a href="#">Download Full Toolkit</a></p> <p><a href="#">Patches, Archives, and Version History</a></p>



**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)

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**Technology Area**

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

Project Count



## 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)

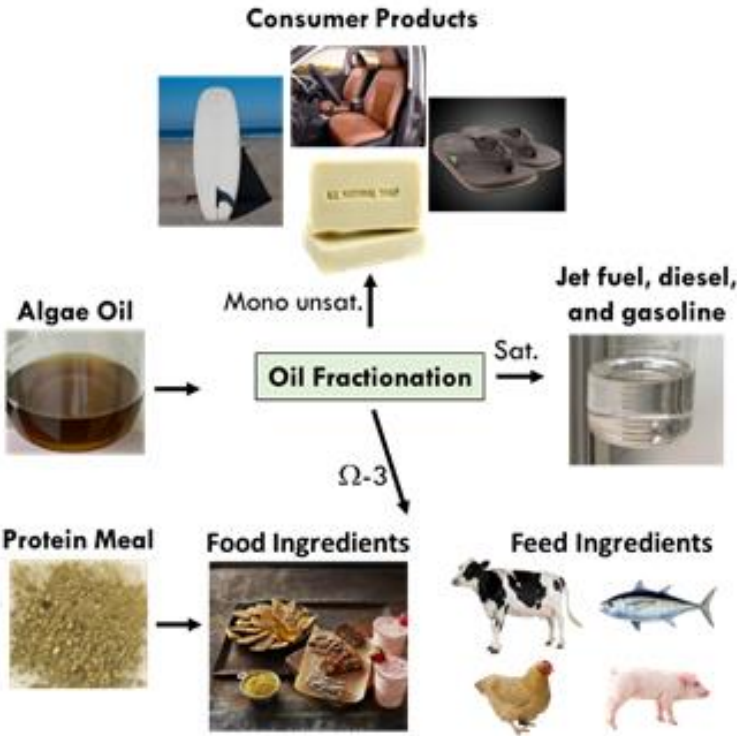
## Advantages and challenges

- 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

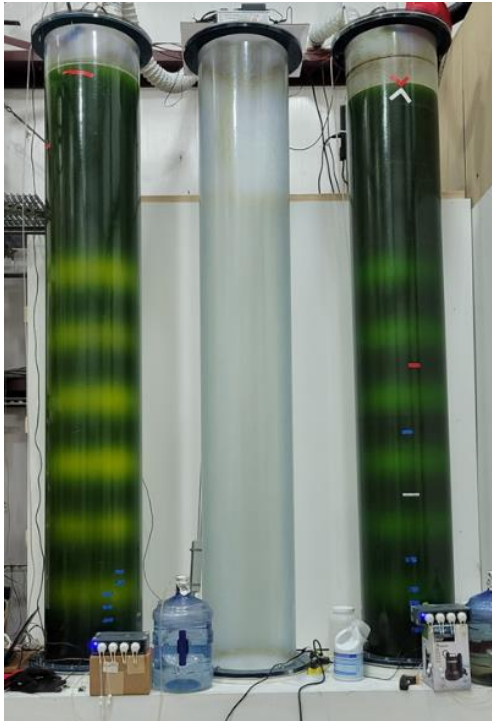
# Carbon Conversion via Biological Uptake



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

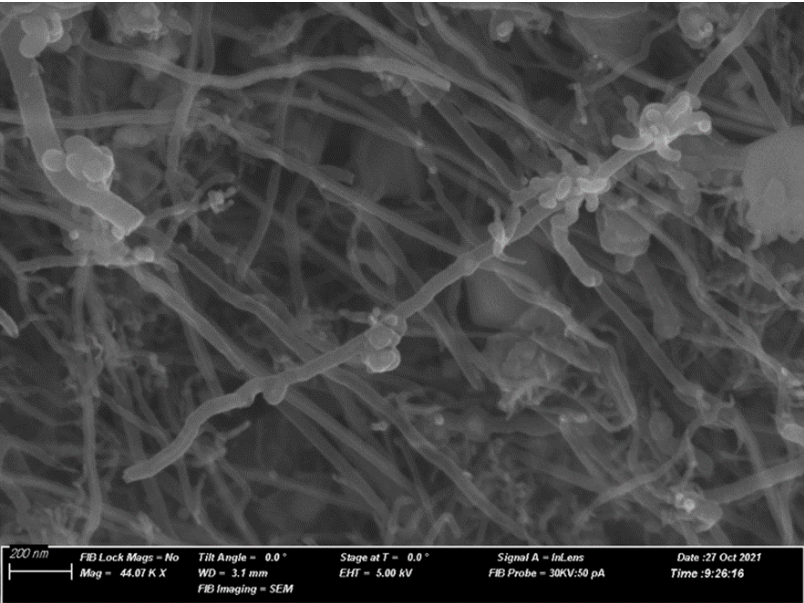
- Fuels
- Polymers
- Solid carbons
- Alcohols
- C2-C4 products (ethane, propane, butane, etc...)
- Methanol and Methane

## Advantages and challenges

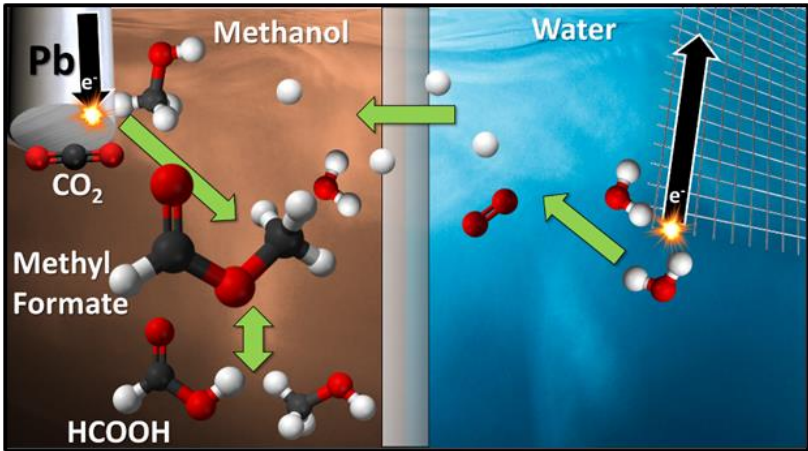
- Pathways to gigatonne scale exist
- Almost any molecule can be synthesized
  - Including those currently derived from fossil fuels
- Value of products must outweigh cost of energy inputs
- Breakthroughs may require significant funding (e.g. electrochemistry and catalysts)



# Carbon Conversion via Catalytic Pathway



Picture courtesy of SkyNano



Picture courtesy of University of Louisville

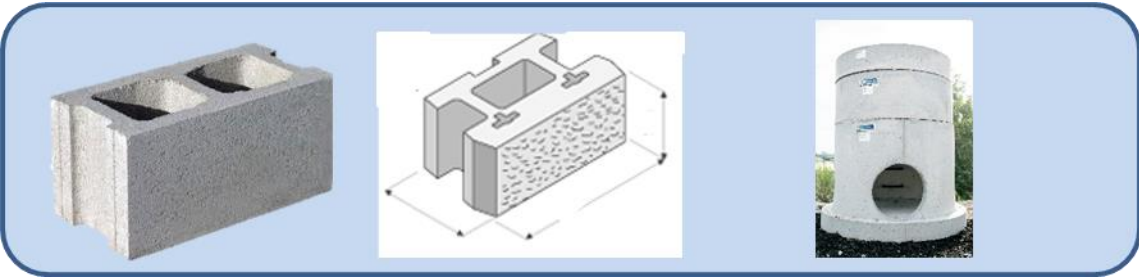
## A limited range of products are possible

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

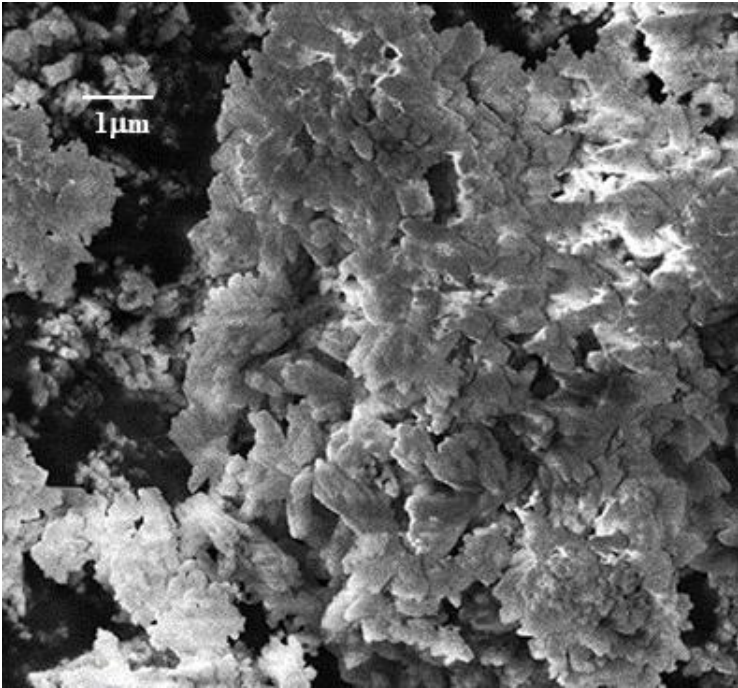
## Advantages and challenges

- 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 CO<sub>2</sub> 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...

# High-Profile Discussion Items

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## **Expanding the program**

- Funding for program is increasing quickly
- Interest is increasing even more quickly than funding

## **Collaboration with multiple stakeholders**

- Necessary due to the scale and breadth of the challenge
- It's not just FECM; lots of other DOE Offices, USG Departments, and NGOs involved

## **Program supports capabilities to test technologies at scale**

- National Carbon Capture Center (NCCC)
- First USG funding source to support UCLA CarbonBuilt technology
  - One of two winners of prestigious NRG COSIA XPRIZE

## **Supporting R&D across multiple pathways**

- Biological, thermos/electro chemical, mineralization, and reactive capture

## **TEA and LCA are vital for an effective program**

- “It’s tough to make predictions, especially about the future”

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