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, Goals, Drivers, Challenges

Mission
• Minimize the climate and environmental impacts of fossil energy
• Advance carbon management through multiple utilization approaches

Goals
• Economically transform CO₂ into products, in an environmentally conscious manner
• Integrated test systems

Drivers
• United States 2020 CO₂ emissions ≈ 4.7 gigatonnes
  • Total global CO₂ emissions in 2021 ≈ 36.3 gigatonnes

Challenges
• Scale of CO₂ emissions relative to CO₂ consumption
• Qualifying economic viability and environmental impact requires significant resources
  • Technical viability is relatively easy to qualify
• Electricity prices rarely negative/free
• “It’s tough to make predictions, especially about the future”
Carbon Utilization Program Structure

Carbon Utilization Program R&D Areas

Focus of other programs

![Graph showing annual funding from FY12 to FY22](image-url)
Carbon Conversion Program Within NETL

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
- Challenges
  - 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, conversion, and biological uptake
High-Profile Items

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

Expanding the program quickly
  • Funding for and interest in the program are increasing quickly
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…
(2) GRANT PROGRAM.—

(A) IN GENERAL.—Not later than 1 year after the date of enactment of the Infrastructure Investment and Jobs Act, the Secretary shall establish a program to provide grants to eligible entities to use in accordance with subparagraph (D).

(B) ELIGIBLE ENTITIES.—To be eligible to receive a grant under this paragraph, an entity shall be—

(i) a State
(ii) a unit of local government
(iii) a public utility or agency.

(D) USE OF FUNDS.—An eligible entity shall use a grant received under this paragraph 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.''};
PP 988 of BIL

(d) AUTHORIZATION OF APPROPRIATIONS.—
Funding totals ~$310MM over five years
$41,000,000 for fiscal year 2022;
$65,250,000 for fiscal year 2023;
$66,562,500 for fiscal year 2024;
$67,940,625 for fiscal year 2025; and
$69,387,656 for fiscal year 2026.
DE-FOA-0002614 – Carbon Management

• FOA released 05/05/2022
• Applications received 07/22/2022
• Multi-program FOA
  • Carbon Conversion
  • Carbon Dioxide Removal
  • Point Source Carbon Capture Technology
  • Carbon Storage Technology
• AOI-1A. Lab-Scale Testing of Mineralization Systems to Generate Commercial Products
Support for R&D on Biological Uptake

DE-FOA-0002654 – Carbon Utilization Technology: Improving Efficient Systems for Algae

- Issued by EERE BETO
- Topic Area 2: Algae-based technology to utilize anthropogenic CO₂ from utility and industrial sources
  - Up to five awards at $2MM each

DE-FOA-0002403 – Engineering-Scale Testing and Validation of Algae-Based Technologies and Bioproducts

- Four selections at ~$2MM DOE share each
- Support for R&D to develop and test technologies that can utilize carbon dioxide from power systems or other industrial sources for bio-mediated uptake by algal systems to create valuable products and services.
- Scale of ~1000 liters
Supporting R&D for Catalytic CO$_2$ Conversion

Largest project count within our portfolio
- The majority of active projects
- Focusing mostly on high volume with some support of R&D into high-value

Several conversion technologies under consideration
- Thermochemical, electrochemical, membrane, molten salt, plasma, microwave
  - Optimal route heavily dependent on CO$_2$ source, raw material costs, and geography

A range of liquid, gas, and solid products
- Formic acid, polymers, ethylene, aromatics, acetic acid, methanol, dimethyl carbonate, propane, propylene, carbon monoxide, nanotubes, graphene, etc…
  - Ensure that we minimize duplication across DOE offices
  - Fundamental tradeoff between high-volume and high-value

Challenges
- Scale of CO$_2$ emissions relative to CO$_2$ consumption
Reactive Capture and Conversion (RCC)

**Newer area of focus within the program**
- Published RFI seeking input on RCC in 2019
- RCC is distinct from other capture technologies
- CO₂ becomes incorporated into the final product and is neither regenerated, transported for further use, nor stored as pure CO₂
- Avoids energy intensive regeneration
  - Adsorption towers are also a relatively expensive component
- [https://www.nrel.gov/docs/fy21osti/78466.pdf](https://www.nrel.gov/docs/fy21osti/78466.pdf)
- [https://www.nrel.gov/bioenergy/workshop-reactive-co2-capture-2020-proceedings.html](https://www.nrel.gov/bioenergy/workshop-reactive-co2-capture-2020-proceedings.html)

**Targeted lab call**
- Focus on conversion or mineralization

**Five national nab projects**
- LLNL – Direct Air Reactive Capture and Conversion for Utility-Scale Energy Storage
- NETL – Integrating CO₂-Selective Polymer Layers and Electrocatalytic Conversion
- NREL – A Pressure-Swing Process for Reactive CO₂ Capture and Conversion to Methanol through Precise Control of Co- Located Active Sites in Dual Functional Materials
- ORNL – Porous Catalytic Polymers for Simultaneous CO₂ Capture and Conversion to Value-added Chemicals
- PNNL Integrated Capture and Conversion of CO₂ into Materials: Pathways for Producing CO₂-Negative Building Composites
Carbon Conversion Contacts and Resources

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https://netl.doe.gov/coal/carbon-utilization